The Engineer.

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VOL. CXXXIX.—No. 3607] LONDON: FRIDAY EVENING FEBRUARY 13, 1925 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director - General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for :—

1. WHEELS and AXLES, 1000 pairs.
2. BODY IRONWORK for RAILWAY CARRIAGES, 13 sets.

Tenders due on Friday, the 27th February, 1925, for No. 1, and on Friday, the 6th March, 1925, for No. 2.

Tender forms obtainable from above. 8362

Section Engineers (6) REQUIRED for the Construction Branch of the FEDERATED MALAY STATES RAILWAYS, for three years' service, with possible extension. Salary 400 dollars a month, rising to 475 dollars a month by annual increments of 25 dollars a month plus a temporary non-pensionable allowance of 10 per cent., which is liable to cancellation or revision, plus a commuted field allowance of 50 dollars a month. The exchange value of the dollar in sterling is at present fixed by the Government at 2s. 4d., but its purchasing power in Malaya is at present considerably less than that of 2s. 4d. in the United Kingdom. Free passage provided. On expiration of agreement a bonus of four and a half months' salary may be allowed provided the work and conduct of the person engaged has been in every way satisfactory. Candidates, age 25 to 38 and unmarried, must be fully qualified railway engineers who have received good training and experience on recognised European, American or Colonial railways. Members or associate members of the Institution of Civil Engineers preferred.—Apply at once by letter, stating age and particulars of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting at top of application M/13,264. 8253

Royal Show.

CHESTER

JULY 7th to 11th, 1925.

EXHIBITION OF IMPLEMENTS, &c.

The Regulations and Forms of Application for Space are now ready.

Applications must be made by

FRIDAY, MARCH 20th, 1925.

Live Stock entries close on MAY 1st; Produce, Forestry and Horticultural Exhibitions on MAY 20th; Poultry on MAY 30th; Dogs on JUNE 19th; Competitions for Plantations, Home Nurseries, Orchards and Fruit Plantations on MAY 1st.

T. B. TURNER, Secretary.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND, 16, Bedford Square, London, W.C.1.

Bombay, Baroda, and Central INDIA RAILWAY CO.

The Directors are prepared to receive up to Noon on Wednesday, 25th February, TENDERS for the SUPPLY of :—

1. BOLTS, NUTS and RIVETS
2. CHEMICALLY DRESSED WAGON COVERS, &c.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 20s. each for No. 1 and 10s. each for No. 2 (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG, Secretary.

Offices : 91, Petty France, Westminster, S.W. 1. 9th February, 1925. 8342

City of Chichester. WATERWORKS. PUMPING MACHINERY.

The Town Council of the City of Chichester invites TENDERS for the SUPPLY and ERECTION of a FOUR-STAGE CENTRIFUGAL or other type PUMP and suitable ELECTRIC MOTOR to drive same, with other appurtenant Fittings. Capacity 50,000 gallons per hour, total head 350ft. Electricity at 415 volts, 3 phase, 50 cycles. Further details and form of Tender can be obtained from the City Engineer and Surveyor, Frank J. Lobley, A.M.I.C.E., North-street, Chichester, during usual office hours.

The lowest or any Tender not necessarily accepted. Tenders, in sealed envelopes, suitably endorsed, to be delivered at my office not later than Tuesday, the 24th day of February, 1925.

By Order, J. W. LOADER COOPER, Town Clerk.

Town Clerk's Office, Chichester, 9th February, 1925. 8328

Parish of St. George in the East. TENDERS FOR PROVIDING NEW BALCONIES TO WARDS.

The Guardians of the above-named Parish invite TENDERS for PROVIDING and FIXING NEW BALCONIES to certain wards at the Hospital at Raine-street, Old Gravel-lane, E. 1.

Specification and form of Tender may be obtained at my office, or will be forwarded upon receipt of postage (3d.).

Sealed Tenders must be delivered to me by not later than 1 p.m. on Thursday, the 26th February, 1925.

By Order, R. M. LOCHNER, Clerk.

Guardians' Offices, Raine-street, Old Gravel-lane, E. 1. 6th February, 1925. 8317

The Engineer

PRINCIPAL CONTENTS OF THIS ISSUE.

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The British Steam Railway Locomotive from 1825 to 1924—No. 7.

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The Kelvin Lecture: Electric Forces and Quanta.

Heavy Duty Anti-friction Bearings.

The Internal Combustion Boiler.

The Heaviside Layer.

Post Office Engineering Work.

PUBLIC NOTICES

City of Hull Tramways. TO STEEL ROOF BUILDERS. COTTINGHAM-ROAD CAR SHED EXTENSION.

The Corporation is prepared to receive TENDERS for STEEL ROOF PRINCIPALS, LATTICE GIRDERS, and ROLLED JOIST STANCHIONS, amounting altogether to about 75 tons.

Forms of Tender and other particulars may be obtained of the undersigned on payment of £1, returnable to firms submitting a bona fide Tender. Prints of the contract plans can be obtained on payment of 5s., not returnable. Remittances must be made payable to Mr. T. G. Milner, City Treasurer and Accountant.

Tenders, endorsed "Tender for Car Shed Roofs," are to be addressed to the Chairman of the Tramways Committee, and delivered at the Town Clerk's Office, Hull, before Noon on Monday, the 23rd February.

The Corporation does not bind itself to accept the lowest or any Tender.

By order, F. W. BRICKNELL, City Engineer.

Guildhall, Hull, 10th February, 1925. 8352

County Borough of Salford. ELECTRICITY DEPARTMENT. PLANT FOR IMMEDIATE DISPOSAL.

(A) 1 TURBO-ALTERNATOR of a capacity of 5000 K.W., with 160 lb. steam pressure at the stop valve, 1500 r.p.m., 6600 volts, 50 periods, complete with surface condenser of 11,500 sq. ft. cooling surface, motor-driven circulating pump, also steam-driven air pump and steam air ejector.

(B) 8 LANCASHIRE BOILERS, 9ft. diameter by 30ft. long, fitted with mechanical stokers and superheaters, all in working order, and guaranteed for a pressure of 165 lb. per square inch.

(C) 2 STACKS of GREEN'S CAST IRON ECONOMISERS, each with 400 tubes, complete for a pressure of 200 lb. per square inch.

The whole of the above plant is in daily use and can be seen in commission by arrangement.

Full particulars and forms of Tender may be obtained on application to the Borough Electrical Engineer, Electricity Works, Frederick-road, Pendleton.

Tenders should be received not later than Twelve Noon on Monday, the 23rd instant.

8257 L. C. EVANS, Town Clerk.

BELFAST HARBOUR.

The Belfast Harbour Commissioners invite TENDERS for the CONSTRUCTION, ERECTION and SETTING to WORK of ONE ELECTRICALLY DRIVEN TRAVELLING CRANE (3-phase, A.C., 380 volts, 50 cycles). The crane is to be erected on the Abercorn Basin, Belfast, where pointed out.

Outline specification, form of Tender, and any further information required may be obtained from the Harbour Engineer, Mr. T. S. Gilbert, M. Inst. C.E.

Tenders must be made on the special form provided for the purpose, and enclosed in a sealed envelope, addressed to the undersigned and endorsed "Tender for Electric Crane," and delivered on or before Wednesday, the 11th March, 1925.

The Commissioners do not bind themselves to accept the lowest or any Tender.

M. J. WATKINS, General Manager and Secretary.

Harbour Office, Belfast, 6th February, 1925. 8330

TO MANUFACTURERS ONLY.

The Directors of Irish Co-operative Meat, Ltd., invite TENDERS for the SUPPLY and ERECTION of POWER and REFRIGERATING MACHINERY for a Meat Factory at Waterford. Copies of blue prints and specification can be had from the undersigned at 52, The Quay, Waterford, Ireland, upon payment of £1 1s.

P. COURTNEY, Secretary.

8230

PUBLIC NOTICES

The South Indian Railway Company, Limited.

The Directors are prepared to receive TENDERS for the SUPPLY of :—

STEEL WORK FOR BRIDGES.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Steel Work for Bridges," must be left with the undersigned not later than Twelve Noon on Friday, the 17th April, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of the specification.

Copies of the drawings may be obtained at the offices of the Company's Consulting Engineers, Messrs. Robert White and Partners, 3, Victoria-street, Westminster, S.W. 1.

A. MUIRHEAD, Managing Director.

91, Petty France, S.W. 1, 10th February, 1925. 8375

Bombay, Baroda, and Central INDIA RAILWAY.

TEMPORARY ASSISTANT ENGINEER FOR SIGNALLING AND ENGINEERING WORKSHOP, BOMBAY.

The Directors are prepared to receive APPLICATIONS (by letter only) from properly qualified candidates for the above POST, who must be qualified Interlocking and Signal Engineers, and be able to establish and manage a small workshop for the manufacture and re-conditioning of Signalling and Interlocking Material. The shop will consist mainly of Smithy, Carpenters' Shop, Fitting and Connecting Shop, Machine Shop, and Stores Yard.

SALARY.—Rs. 750 per calendar month, plus local allowances according to the scales in force.

TERMS.—A three years' agreement, first-class free passage to India and home again on satisfactory termination of services.

The selected candidate will be required to pass a strict medical examination by the Company's Consulting Physician before appointment.

Applications should give full particulars of age, whether married or single, where apprenticeship or pupilage was served, with special details as to the applicant's experience as an interlocking and signal engineer, and of the work he has carried out in the actual manufacture and re-conditioning of signalling and interlocking material. These particulars should be received by the undersigned not later than the 28th February, 1925.

S. G. S. YOUNG, Secretary.

Offices : The White Mansion, 91, Petty France, Westminster, S.W. 1, 11th February, 1925. 8374

SITUATIONS OPEN

WANTED, an Experienced ENGINEER, for a Chemical Works near London.—Address, stating age, training, and salary required, sending copies of testimonials, 8238, The Engineer Office. 8238 A

CENTRIFUGAL PUMP DESIGNER.—An Important FIRM REQUIRE the SERVICES of an EXPERT, to devote his whole time to the hydraulic side of Centrifugal Pump Design.—Address in confidence, giving full particulars, 8327, The Engineer Office. 8327 A

ESTIMATOR REQUIRED, Capable of Making Estimates from project drawings for Mechanical Handling Plants for coal and other materials. Only men with good experience and proved abilities need apply. State age, experience, and salary required.—Address, 8165, The Engineer Office. 8165 A

SITUATIONS OPEN (continued)

ESTIMATOR WANTED for Engineering Works; must be capable all-round man, shop trained with drawing-office experience, and be able to work out weights and prices of Light and Heavy Castings, all kinds of Structural Work, Mining and general Machinery. None but first-class men need apply.—Write, stating age, experience and salary required, Box 543, Sells' Advertising Offices, Fleet-street, E.C. 4. 8366 A

EXPERIENCED ENGINEER REQUIRED by Large General Engineering Firm (London district), to Assist Chief Inspector. Must have had a wide experience on the inspection of high-class interchangeable parts to close limits and to pass Government inspectors, both during production and after assembly; must also have been previously employed in a similar capacity.—Address, stating age, salary required, and details of experience in chronological order, 8320, The Engineer Office. 8320 A

KEEN Young ENGINEER REQUIRED, to Take Charge of Small Manufacturing Plant in London. Must have good shop and D.O. training. State fully experience, age, salary expected, &c.—Address, P241, The Engineer Office. P241 A

MAN for RATE FIXING and PROCESSING REQUIRED for Aero-engine Works. Must be capable of laying out complete sequence of operations and estimating times. State age, experience, and salary required.—Address, 8321, The Engineer Office. 8321 A

RATEFIXER WANTED, with Experience Piece work prices, Machinery Fitting and Erecting, various classes Engine Work. Only those with proved experience need apply.—Write, stating age, salary required, and full particulars experience, Box 546, Sells' Advertising Offices, Fleet-street, E.C. 4. 8368 A

REQUIRED for British Engineering Works in India, an ENGINEER as SENIOR ASSISTANT to the management, experienced in Bridge and Steel Constructional Work; applicants must have thorough Workshops, Drawing-office, Designing and Estimating Experience. None but experienced men need apply. Age, 30 to 38.—Write, stating age and giving full particulars of previous experience, to "Z.L. 777," c.o. Deacon's, Leadenhall-street, London, E.C. 3. 8291 A

STRUCTURAL STEEL WORK.—First-class DESIGNER and ESTIMATOR REQUIRED by well-known Manchester firm. Thoroughly conversant with the design of Steel Work for Factories, Warehouses, and Office Buildings. Only men acting in similar capacity will be considered.—Address, stating age, details of experience, and salary required, with references to recent employers, 8361, The Engineer Office. 8361 A

SUPERINTENDENT ENGINEER REQUIRED, with civil and mechanical training, preferably associate member of recognised institution, competent to manage workshops and maintenance plant, including power plant, machine shops, electricians, smiths, joiners, bricklayers, in important works in a district accessible to Manchester and Liverpool and engaged in a branch of the steel industry.

Experience in machinery for Rod Rolling, Wire-drawing and ancillary trades an advantage.

Replies to be typewritten, stating age, qualifications, experience, and salary required.

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DRAUGHTSMEN.—BEFORE NEGOTIATING with Government Departments in connection with any post, PLEASE COMMUNICATE with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's-square, London, S.W. 1. 7871 A

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INDIA.—REQUIRED by a British Firm of Bridge and Structural Engineers, a DRAUGHTSMAN, capable of preparing designs and estimates and experienced in the preparation of working drawings for Bridge and Structural Steel Work. Must be a bachelor, age 24 to 28.
Write, stating age and giving full particulars of previous experience, to Z. A. 788, care Deacon's, Leadenhall-street, London. 8349 A

WANTED, BOILER SHOP FOREMAN, Experienced in construction Vertical and Horizontal Boilers, Cylinders, Tanks, &c. Must have thorough practical knowledge of Plating, Press and Angle Work, Riveting and Fire Welding. Knowledge of prices and ability to set rates an advantage. State age, experience and salary required; send copies only of testimonials.—Address, P255, The Engineer Office. P2o5 A

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No. 123,132, "Draft Tubes for Turbines."
No. 170,926, "Improvements in Hydraulic Turbines."
No. 152,832, "Improvements in Centrifugal and Screw Pumps."
No. 139,414, "Improvements in Hydraulic Turbines."
No. 144,709, "Improvements in Centrifugal and like Pumps."
No. 146,452, "Improvements in Rotary Pumps of the Substantially Axial Flow Type."
No. 161,569, "Improvements in and relating to Hydraulic Turbines."
No. 140,004, "Improvements in Hydraulic Turbines."
No. 171,982, "Improvements in Impulse Turbines."
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For continuation of Small Advertisements see page 3.

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A Seven-Day Journal

African Air Flights.

THE remarkable flight of the French officers Lemaitre and Aerachard from Etampes to Dakar is significant, not so much of what can be accomplished with the aeroplane as of the part which the flying machine is destined to play in the opening up of the French possessions in West Africa. The only thing noteworthy about the flight itself is the steady lengthening of the stages that can be covered, and there is nothing surprising in this development, when engines can be made to run for days on end and when the machines are capable of carrying a large quantity of fuel. The French officers set out with the intention of reaching Dakar in twenty-four hours. They failed to do so through a forced landing at a military post in Spanish territory, but the single flight of 2050 miles in a straight line constitutes a record, and the aviators arrived at Dakar only a few hours later than was intended. Meanwhile, another great feat has been accomplished by two military machines, which have flown from Paris to Timbuctoo, the object being to effect observations. There is no doubt that with their aeroplanes the French have done valuable work in mapping out the almost inaccessible regions in West Africa. The aeroplane, it would seem, is preparing the way for regular transportation by means of motor vehicles, and eventually by railways.

The Rotor Ship at Sea.

IT would appear that Herr Flettner's rotor ship Buckau encountered very stormy weather on her voyage from Danzig to Kiel. The Buckau, it will be remembered, was chartered at Danzig for a cargo of wood, which is to be delivered at Grangemouth. On her previous voyage from Kiel to Danzig the passage was made in forty-four hours, but sixty-eight hours were taken on the return voyage last week-end. With the westerly head wind then prevailing, it was found, it is reported, impossible to make a faster speed than about 4 knots. During the gale in the Baltic Sea on Friday last there were times when the rotors had to be stopped, owing to the heavy seas, and although the wind speed dropped after nightfall from 70ft. per second to half that velocity, the speed of the ship on Saturday did not exceed 5 knots. Towards the end of the trip the Buckau made 7 knots, and she reached Kiel Harbour on Sunday afternoon. After being fitted with a wireless installation, she will leave for the Firth of Forth. Herr Flettner is to deliver a lecture before the Institution of Engineers and Shipbuilders in Scotland next month, and this voyage will no doubt provide some interesting results as to the actual operation of the ship in commercial service. It may be borne in mind that the inventor only claims the rotor principle to be an auxiliary means of propulsion.

Birmingham—Liverpool Canal.

ON Friday, February 6th, the Birmingham Corporation decided to investigate further the proposal of the Special Canals Committee for the construction of a 100-ton barge canal between that city and the Mersey. There are, of course, already two canals—the Shropshire Union and the Trent and Mersey—which provide communication with the sea, but they have many drawbacks. The Royal Commission advocated a route from Birmingham, *viâ* Tamworth, which would be about 98 miles long; but the Committee recommends going by way of Wolverhampton and the Potteries, and thus reducing the distance to 82 miles. The new scheme would also serve several important industrial districts. By making a deviation from the present canal between Horseley Fields and Aldersley Junction a flight of locks would be eliminated, while other alterations near Stone and Middlewich would also improve matters. It is estimated that the complete journey could be done in less than thirty-six hours, and that the carrying capacity of the canal might be 6¾ million tons a year. Ample water could be found for the needs of the canal. The cost of the scheme, which has been favourably received in Wolverhampton, is put at about £6,600,000.

Wireless Telephones for Ships.

EXPERIMENTS are at present being undertaken at Southampton with a view to providing a wireless telephone service between ships and shore, which may be linked up with the General Post Office land telephone lines. These experiments, which are being conducted by the Marconi Company in conjunction with the General Post Office and the Southern Railway Company, have shown that a perfect commercial service could be undertaken if suitable wave lengths free from mutual interference between the service and existing broadcasting stations could be allotted. For use in connection with the tests a special duplex wireless telephone set has been designed by the Marconi Company, and the problems connected with duplex telephony between ships and the shore and the linking of such a system with the Post Office land telephone lines is said to have been solved. Additional experimental work will, however, be necessary in order to fit in a service of this nature with the existing wireless services without mutual interference. By the courtesy of the General Post Office the land station for these experiments has been established at the sectional engineer's office at Millbrook, Southampton, where all necessary accommodation and and other facilities have been provided. Under good conditions perfectly satisfactory simplex communication has been obtained between the Southern Railway Company's steamship Princess Ena at sea and Southampton up to a distance of about 200 miles, and a reliable duplex communication has been secured up to a distance of 100 miles, except at moments of exceptionally strong jamming. Moreover, satisfactory commercial communication from city offices to the ship over long land lines, such as from offices in London to Southampton and thence by wireless to the ship, have been obtained when the Princess Ena has been 50 miles from the shore.

Wolverhampton Sewage Works.

THE Wolverhampton Corporation decided on Monday on a very extensive housing scheme and also on a new system of sewage purification, which it is estimated will cost £50,000. It is proposed to adopt the activated sludge system, and to construct plant capable of dealing with 2½ million gallons daily. The chief advantage of the system is, of course, the comparatively small area the plant required occupies, and it is estimated that 50 acres will be sufficient to deal with the extra sewage from the new housing estates, and the trade waste from Courtauld's new factory. The extra charges entailed by the scheme, including capital charges, are put at £6432 a year; but if the whole of the local sewage is subsequently treated by the new method, an area of 600 acres of sewage farm land will be liberated, and an annual saving of £2500 effected.

Wireless Communication with the Hamilton Rice Expedition.

WHILST receiving Morse signals from an American wireless station, Mr. Gerald Marcuse, the well-known English amateur wireless experimenter, accidentally picked up a message from the wireless operator with the Hamilton Rice Expedition, which is now going up the river Amazon. Two-way communication was carried on, and the operator with the expedition gave Mr. Marcuse a message for the Royal Geographical Society, stating that the expedition had arrived at the junction of the rivers Urari and Uricatara on January 19th. Owing to the extremely difficult conditions of the country, the message went on to state, the hydroplane could not be used, but the object of the expedition had been attained and all was well. The distance over which the message was sent is estimated at about 7000 miles. The message was duly forwarded to the Royal Geographical Society, which gave Mr. Marcuse its reply, which he succeeded in transmitting to the expedition. The transmission is said to have been exceedingly good, and he was able to deliver the message with the repetition of only one word.

Coal Transporters for Port Sudan.

FURTHER to the particulars regarding the large Sudan engineering projects, which were given in our North Country letter last week, we are in a position to state that in addition to the bridge over the Nile, and the tramway and waterworks schemes, a large coal handling plant will be erected at Port Sudan. The order for this plant has been received from the Sudan Government by Sir William Arrol and Co., Limited. The plant will be built at the firm's crane works at Parkhead, Glasgow, and will, it is hoped, be ready for erection in about a year's time. It comprises four electrically-driven travelling and slewing bridge transporters, each of which will have a span of 215ft. and an overall length of 425ft., with a height of lift above the rails of 45ft. The transporters will, we learn, be equipped with high-speed grabs of the Temperley patented type, and are each to be designed for an output of 100 tons of coal per hour, carried from the ship to the centre of the span. Two-ton grabs will be employed. A special feature of the machines—apart from their exceptional size—will be the combined slewing and travelling motion, which will enable the transporter to pick up its load from a fixed point and to distribute coal over a very large storage area.

Manchester Waterworks.

AT a meeting of the Waterworks Committee of the Manchester Corporation, held last week, it was decided to recommend the City Council to proceed at once with the Haweswater scheme for increasing the water supply resources of the city, and to appoint Mr. L. Holme Lewis, M. Inst. C.E., to take charge of the work. The estimated cost of the scheme is £10,000,000, The work involved includes 74½ miles of aqueduct from Haweswater to the Heaton Park reservoir. 28 miles of which will be underground. A dam is to be built at the northern outlet of the lake, so as to raise the water 95ft., to the 800ft. contour line, and the water will be drawn off from the other end. A 4-mile tunnel under the fells will take the water to the head of Long Sleddale, where a five-pipe line will commence, and will follow the valley down to Garnett Bridge, near Kendal, within a mile of the Thirlmere pipe line, with which a connection will be made. The Haweswater pipes will, however, continue separately on a higher route than that followed by those from Thirlmere. They will go on to Kirkby Lonsdale, across the Lune, and then go underground again under the moors of the Forset of Bowland by a tunnel 8½ miles long. Then passing over the river Hodder, the lines will again go underground to Bashall Eves. The industrial area of Lancashire will be entered above Accrington, whence there will be a tunnel 9 miles long, which will deliver the water to Woodgate Hill reservoir, north of Bury. Thence the water will be carried above ground to Heaton Park reservoir. The supply of water which the scheme will provide will be 50,000,000 gallons per day, or nearly equal to the present consumption.

The Croydon Air Disaster.

THE report of Sir Arthur Colefax's formal investigation into the causes of the disaster that overtook a de Havilland eleven-seater Imperial Airways machine on December 24th just after it had left Croydon for Paris, was issued by the Air Ministry on Tuesday. The report is signed by Sir Arthur, and by the assessors appointed to act with him—Professor B. M. Jones and Mr. J. Swinburne. No official of the Air Ministry or of Imperial Airways is found to have exhibited negligence, and the pilot is absolved from all blame. The accident is ascribed to loss of control combined with a stall which occurred while the pilot was trying to make a forced landing. In this connection, the report calls attention to the fact that the D.H. 34 type of aeroplane has "an exceptionally high stalling speed," namely, 62 to 63 miles per hour but that it has other exceptional qualities, which in some measure offset the adverse effect of the high stalling speed. For about half the time the machine was in the air, the flight, it is held, was normal. But thereafter some defect developed, the nature of which cannot be discovered, which seems to have induced the pilot to endeavour to alight. The Croydon aerodrome, it is held, is unsatisfactory, but it is not suggested that this fact was more than a contributory cause of the disaster. Suggestions that the machine was overloaded are set aside by the finding that its total weight at the time of the disaster was 40 lb. less than the authorised maximum. Two recommendations are attached to the report. In the first place, it is urged that the Air Ministry should consider the question whether any and what limit should be fixed for the angle of climb and the stalling speed of aircraft intended to carry passengers. Secondly, it is recommended that every endeavour should be made to remove from such aircraft the danger arising from the loss of control associated with stalling. The subject involved in this second recommendation, it may be added, is one the importance of which has long been recognised by designers, and which has engaged their closest attention for years. A vast amount of research work has been conducted on it, but a proportionately successful solution has not yet been discovered.

Wages in the Engineering Industry.

A CONFERENCE held in London on Tuesday and Wednesday, between the Engineering Employers' Federation and the representatives of the various trades unions associated with the engineering industry, came to a close on the second day without any definite decision being arrived at concerning the men's claim for a flat rate advance of 20s. per week in the wages of all adult workers. It is understood that the employers proposed the setting up of a joint committee to consider the wage question in relation to the present condition and prospects of the industry, and that there was a sharp division of opinion among the union representatives as to what attitude should be adopted towards this proposal. Apparently those against agreeing to it won the day, for on Wednesday, it is gathered, the employers intimated that they would be prepared to consider an advance in wages if the unions would agree to a modification of existing workshop conditions such as would cover the additional wages costs. The union representatives replied that as no offer of a definite advance had been made they could not proceed further without reporting to their executives. They expressed their regret that the employers had introduced the subject of working conditions. The union representatives will meet again on March 4th to receive the views of the different executives and to decide upon their further course of action. It is probable that the unions will decide to ask for another meeting with the employers, and to press for a definite statement as to the amount of the advance to be given, and the precise nature of the modification desired by the employers in the working conditions.

The British Steam Railway Locomotive from 1825 to 1924.

By E. L. AHRONS, M.I. Mech. E.

No. VII.*

PERIOD 1841 TO 1845.

THE principal feature of this period was the introduction and development by R. Stephenson and Co. of the "long boiler" engine, and the temporary abandonment by this and some other firms of what may be termed the "standard" locomotive, evolved from Stephenson's "Patentee" of 1833. The standard six-wheeled engine had the trailing wheels behind the fire-box, but in the long boiler engine all three axles were in front of it.

Before considering the long boiler locomotive it will be more convenient to follow the Hackworth and other schools, and also deal with the progress of the standard engine, of which another outside cylinder type appeared.

Stockton and Darlington Railway and Later Hackworth Engines.—Although the last engines designed by T. Hackworth for the Stockton and Darlington Railway were built in 1842, his designs still continued to affect the type of engine on that line. Amongst the Hackworth features retained were the steeply inclined cylinders, cast iron plug wheels, and to some extent the combined flue and return multitubular boiler. Some engines by W. and A. Kitching from 1845 onwards had the inclined cylinders attached to the boiler at the back, the connecting-rods driving the leading wheels. These were of the "Derwent" class—see THE ENGINEER, October 29th, 1920—of which the last came out in January, 1848. It had the Hackworth boiler mentioned above, 4ft. cast iron wheels, and 14½in. by 24in. cylinders. At the same period six engines—Fig. 42—were built at the Shildon works of the company in 1845–6, in which William Bouch, the locomotive superintendent, introduced important modifications. The steeply inclined cylinders were retained, but were attached to the boiler at the smoke-box end, the connecting-rods driving the rear pair of wheels. Steam was taken from the dome through a large external elbow pipe to valve chests above the cylinders, and the exhaust pipe to the smoke-box was also outside. A form of gab motion with very long valve spindles was used. The Hackworth flue boiler was abandoned, and a long multitubular boiler 13ft. long with 213 1¾in. tubes substituted. The grate area was only 10 square feet, the fire-box being too small for the boiler, which had a total heating surface of 1363 square feet, pressure 75 lb. The weight was very unevenly distributed; of the total of 22 tons 7 cwt., 8 tons 15 cwt. were carried at the driving wheels, and only 5 tons 18 cwt. at the leading wheels. Two tenders with small 2ft. wheels were attached, one at each end, though one would have sufficed.

Of another type of engine by T. Hackworth unfortunately no detailed particulars appear to have been preserved. A few were built at his own works at Shildon. Their special feature was outside horizontal cylinders situated at the trailing end. Joseph Tomlinson ("Proc.," Inst. Mech. Engrs., 1890) stated that they were the first to be built with outside horizontal cylinders, but it is doubtful whether they preceded the Rennie engines of 1839 for the London and Croydon Railway. A similar type was afterwards built by Fossick and Hackworth, of Stockton, for the Stockton and Hartlepool Railways. The firm of Fossick and Hackworth was founded about 1840 by Thomas Hackworth, the brother of Timothy, who carried on at Stockton many of the traditions originated at Shildon, and until 1864 built engines with inclined cylinders attached to the boiler.

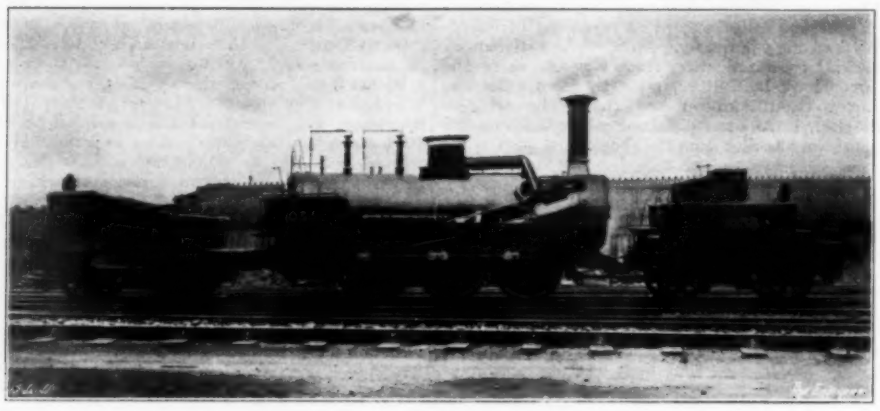


FIG. 42—STOCKTON AND DARLINGTON LOCOMOTIVE, 1845-6

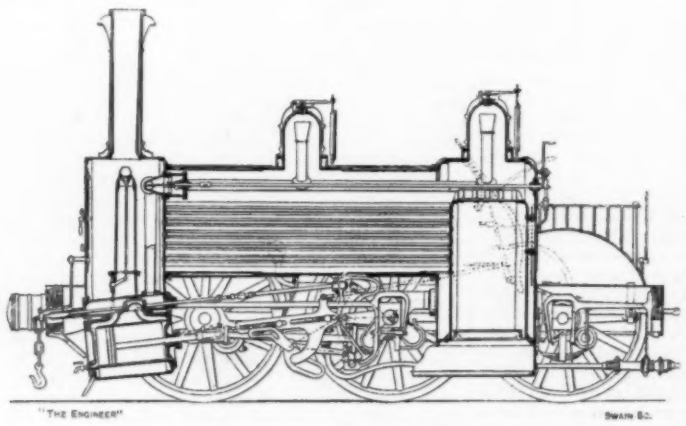


FIG. 43—GRAY'S HULL AND SELBY ENGINE, 1842-44

Bury Type Engines.—Bury held tenaciously to the four-wheeled bar framed locomotive, merely enlarging the dimensions, though in 1845 his passenger engines, with 5ft. 9in. driving wheels, had only 14in. by 18in. cylinders. The 0–4–0 goods engines were built with 5ft. wheels and 14in. by 24in. cylinders. The only firms which followed Bury's practice during this period were B. Hick and Son, the Haigh Foundry, and W. Fairbairn and Sons, though the last-named firm confined itself strictly to four-wheeled bar-framed goods engines, and built its passenger engines of the 2–2–2 outside-framed Stephenson type.

But at the end of 1845 Bury was compelled to adopt the six-wheeled engine, owing partly to the increasing weight of trains and also to the pressure of technical opinion, but he retained the bar frames.

Standard Engines with Inside Cylinders.—Of the "standard" inside cylinder engines the 0–6–0 locomotives designed by John Gray for the Hull and Selby Railway merit attention. Six—Fig. 43—were built 1842 to 1844 by Shepherd and Todd and at the company's shops at Hull. The coupled wheels were 5ft. 6in. diameter and the cylinders (inclined upwards) 16in. by 24in. The boiler pressure, at least in the later engines, was 100 lb. The valve gear was Gray's "horse-leg" motion. A peculiar feature was that the leading wheels only had outside bearings and the coupling rods worked on pins of the form of cranked shafts between the frames and the wheels. Gray's object appears to have been to space the leading springs as widely apart as possible to prevent "rolling" of the engine, since he pitched his boilers at a considerable height above rail level.

Certain firms did not adopt Stephenson's patent long boiler engine. Amongst them was R. and W. Hawthorn, who at this period adhered to the "standard" engine for all classes, passenger and goods. A very fine 2–2–2 express engine, the Richmond, was built by this firm for the Great North of England Railway in May, 1845, but unfortunately no drawings of it exist. It had inside cylinders 16in. by 21in., outside sandwich frames, and 6ft. 6in. driving wheels. W. Tomlinson (History of the N.E.R.) records that in August, 1845, it took a train of seven coaches from Darlington to York, 44½ miles, at an average speed of 51 miles per hour.

Sharp Brothers and W. Fairbairn and Sons rarely built "long boiler" passenger engines, though they subsequently adopted the principle for goods engines. Their 2–2–2 passenger engines of this period were simply enlargements of the engine—Fig. 32 *ante*. An interesting example of this type was the Stockton and Darlington engine No. 50, "Meteor"—Fig. 44—designed by Bouch after the pattern of a "Sharp" and built at the company's works at Shildon, 1843. This engine had 5ft. 2in. driving wheels and 13in. by 20in. cylinders.

The 2–2–2 engines of the Liverpool and Manchester Railway—Fig. 45[1]—designed by John Dewrance, were noted for their neatness. They were known as the "Bird" class on account of the names of birds which they bore, and all were built in 1841–1844 at the company's own works at Edgehill, Liverpool. They were of comparatively small size with 12in. by 18in. cylinders, 5ft. driving wheels, and 3ft. 6in. carrying wheels. Their chief feature was the solid forged wrought iron wheel centres, the first of the sort. The fire-box side stays were not riveted over inside the box, but had long projecting heads shaped like the frustrum of a pyramid. As coke was the fuel used there was no flame licking action, though abrasion was caused by particles of coke, and plenty of material was left on the heads to allow for this wear. The average weight of these engines in working order was 15¼ tons. The small size of the engines used on the Liverpool and Manchester Railway in comparison with those on other railways in 1845 was commented on during the Gauge Commission.

In 1843 the oldest locomotive building firm in the kingdom, Messrs. Fenton, Murray and Jackson, of Leeds, dropped out of existence.

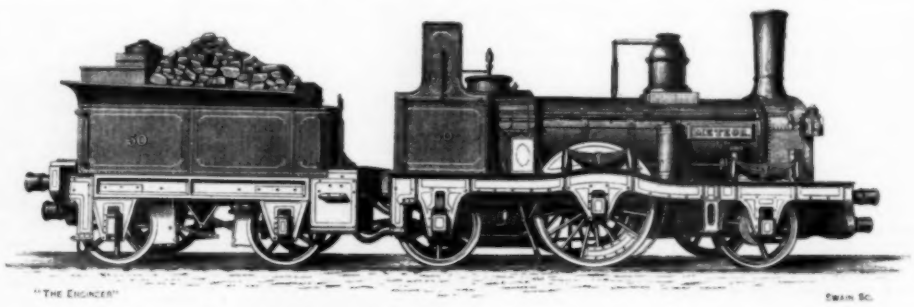


FIG. 44—STOCKTON AND DARLINGTON ENGINE METEOR, 1850

The Crewe Type of Outside Cylinder Locomotive.—The development of the outside cylinder engine by the "Crewe" school was an important epoch in locomotive history, since a type was introduced which had great influence on the locomotive design of several important railways for more than forty years, and at one period largely affected French practice. At the end of 1840 Alexander Allan was works manager of the Grand Junction Railway at Liverpool, and Buddicom was locomotive superintendent. The stock of locomotives then consisted of about seventy 2–2–2 engines with inside cylinders, outside frames and crank axles. The G.J.R. had junctions with the L. and M.R. near Newton-le-Willows by means of two sharp curves, in running over which a considerable number of crank axles were broken. Allan, prompted by his previous experience with G. Forrester and Co., obtained permission to reconstruct three of the engines with straight driving axles and outside cylinders. As in Forrester's engines, the cylinders were firmly secured between the inside and outside frames. The frames, together with the motion, were entirely new, but the crank pins were fixed directly in the driving wheels. There is some, though uncertain, evidence that the first two engines may have had outside cranks and bearings for the driving axle, as in Forrester's "boxer" design, but the third engine was certainly of the "Crewe" type, in which only the two carrying axles had outside bearings. After a number of these engines had been reconstructed with the old boilers, 5ft. 6in. wheels and 13in. by 20in. cylinders, the G.J.R. shops were removed to Crewe in 1843, where entirely new engines of the type were built.

The type as developed at Crewe in 1845–1846—Fig. 46—had 6ft. driving wheels, 3ft. 6in. carrying

* No. VI. appeared February 6th.

[1] The illustration Fig. 45 is from a drawing kindly supplied by Sir John Dewrance, who is the son of the late John Dewrance, locomotive superintendent of the L. and M. Railway. The latter died in 1861.

wheels, and 15in. by 20in. cylinders. Wheel base leading to driving, 5ft. 6in.; driving to trailing, 6ft. 6in.; heating surface of tubes, 650 square feet; of fire-box, 51 square feet; total, 709 square feet; grate area, 10.5 square feet; weight in working order, 18 tons, of which about 9 tons rested on the driving wheels. The cylinders, slightly inclined, were placed well forward, and securely fixed between the inside and outside framing. To obtain as long a connecting-rod as possible, the small end was forked with two short arms, which took hold of gudgeon journals on each side of the crosshead. This form of crosshead, designed by Allan in 1840, was standard in all Crewe-built simple engines, both with outside and inside cylinders, until the end of F. W. Webb's superintendency. In the earlier engines of 1845–8 the valves, though working on vertical faces at the sides of the cylinders, were actuated through the medium of rocking shafts. This awkward indirect motion necessitated both excentric rods being inclined downwards, with the Stephenson expansion link in a very low position. In engines built after 1848 direct motion was used.

The Allan type of passenger engine was built at Crewe until the end of 1858, and also became standard on the Caledonian, and many other Scottish railways, including the Highland.

The 2–4–0 "Crewe" goods engine also by Allan, was first built in 1844. It was similar in general design to the passenger engine, but had coupled driving and trailing wheels, 5ft. diameter. The cylinders were 15in. by 20in.—the first engine of 1844 had 13in. by 20in. cylinders—enlarged in later engines to 15½in. by 20in. Weight about 19¼ tons. Many of these engines were built, and the design formed the basis of the later Caledonian passenger and fast goods engines until 1877.

It has been incorrectly stated that the "Crewe" coupled goods engines were the earliest to have the 2–4–0 wheel arrangement. Inside cylinder 2–4–0 engines were in use from 1837 onwards, and some with outside cylinders had been built by R. Stephenson and Co. for abroad before Allan's first engine appeared.

The largest standard gauge express engines of this period of similar type to the "Crewe" engines were built at Nine Elms Works in 1843–4 by the L. and S.W.R. to the designs of John V. Gooch. They had large driving wheels, 6ft. 6in. diameter, and cylinders, 14½in. by 21in.; wheel base, 12ft. 8½in.; total heating surface, 899 square feet. The boiler was domeless and steam was taken from the open end of a long steam pipe at a point above the back of the fire-box. Thence it was conducted to a slide valve gridiron regulator placed between the outside cylinders at the bottom of the smoke-box. This form of regulator, placed over the steam chest, was due to R. Stephenson and Co. in 1841, but Warren adds that it did not survive long in this firm's designs. Gooch, however, used it in nearly all his engines on the L. and S.W. Rly., and afterwards on the Eastern Counties Railway until about 1856. The second boiler ring from the front was dished inwards at each side to allow room for the Gooch expansion link. The ⅜in. inside frame plates were joggled 2⅜in. each side at the back to accommodate a wider fire-box. The latter had a transverse partition with corrugated sides. These engines are illustrated in D. K. Clark's "Railway Machinery," Plates X. and XI.

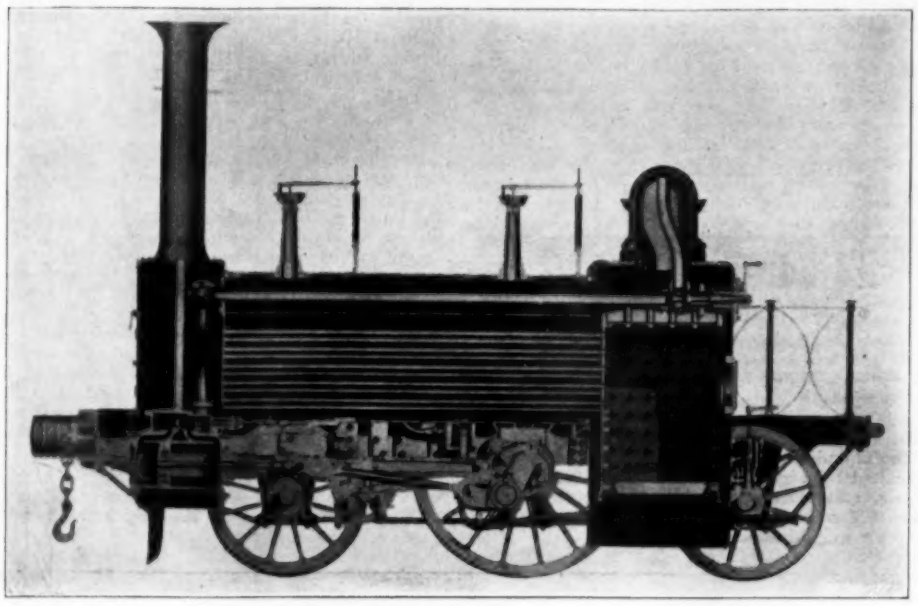


FIG. 45—DEWRANCE'S LIVERPOOL AND MANCHESTER ENGINE, 1841

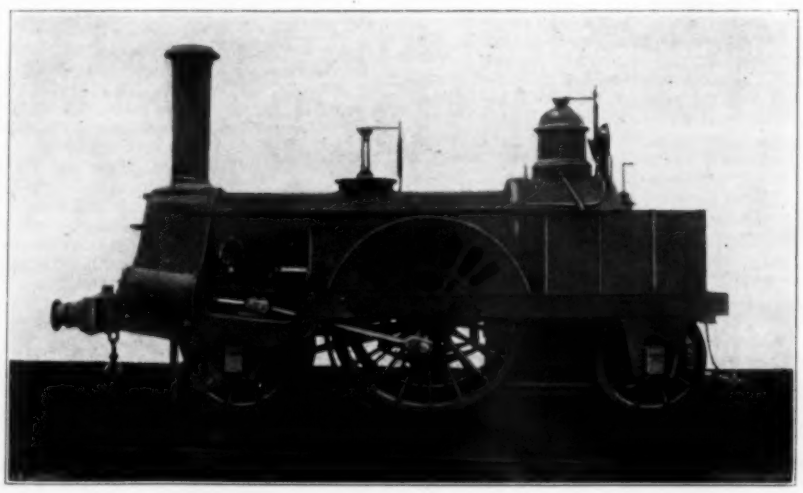


FIG. 46—ALLAN'S "CREWE" TYPE ENGINE, 1845

Long Boiler Engines: Stephenson's Patent.—The long boiler engine, in which all three axles were placed underneath the boiler in front of the fire-box, was introduced by R. Stephenson in 1841, with the principal object of providing greater boiler power accompanied by reduced loss of heat and unburnt fuel through smoke-box and chimney. Two additional factors of importance were the supposed necessity for having the centre of gravity of the engine as low as possible, and the small turntables which necessitated an engine wheel base restricted to about 12ft.

The low centre of gravity theory was maintained as a cardinal principle by every engineer of that day, with the exception of John Gray. It had the effect of limiting the diameter of the boiler in passenger engines with large driving wheels so that when engines of greater power became necessary, R. Stephenson decided to increase the heating surface by lengthening the tubes. For a complete account of the reasons which caused Robert Stephenson to design the "long boiler" engine, see Warren, Chap. XXVI., page 346.

The boiler barrels of that day were about 8ft. to 8ft. 6in. long and 3ft. 6in. to 3ft. 8in. diameter. The fire-box was without a brick arch, and an enormous amount of heat was carried away, as proved by experiments carried out on the North Midland Railway. In estimating the merits of long boiler engines, this and the other factors mentioned must be kept in mind.

The first long boiler engines were of the 2–2–2 type, with inside cylinders, 14in. by 20in., and 5ft. 6in. driving wheels. They appeared in the latter part of 1841, one on the York and North Midland Railway, and the other on the Northern and Eastern Railway (5ft. gauge), from London to Bishop's Stortford. The latter engine is shown in Fig. 47. The boiler barrel was 11ft. 3in. long by 3ft. 2in. outside diameter, its centre being 5ft. 7in. above rail level. The leading wheels had a diameter of 3ft. and the wheel base was 6ft. 4½in. + 4ft. 4½in.

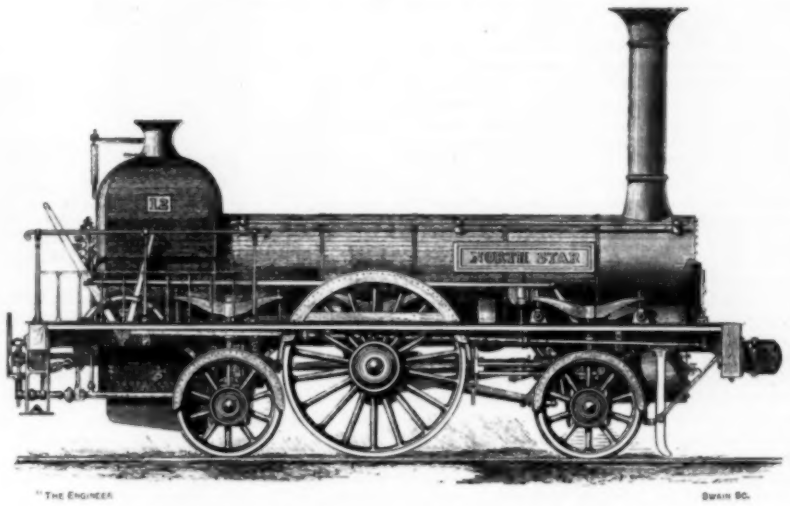


FIG. 47—STEPHENSON'S "LONG BOILER" PASSENGER ENGINE, 1841

This engine presented several novel details. Outside sandwich frames were discarded and the main frames, consisting of ¾in. iron plates which extended the whole length of the engine, were placed inside the wheels. In deciding upon this form of framing, R. Stephenson had been influenced by the serviceability of Bury's inside frames—Warren, page 350. The cylinders were bolted together, and the steam chest, instead of being above the cylinders, was placed between them and was common to both, the valves working on vertical faces. This improvement, used to this day in most British inside cylinder engines with slide valves, was due to R. Stephenson and Co.

This type of passenger engine was built for various railways at home and abroad until the end of 1845. A similar but larger engine by Kitson Thompson and Hewitson, 1845, for the North Midland Railway—THE ENGINEER, November 23rd, 1923—had 5ft. 6in. driving wheels, 15in. by 22in. cylinders, 11ft. 3in. total wheel base, boiler barrel 13ft. long by 3ft. 5in. diameter, 123 tubes 1¾in. diameter, which gave a heating surface of 799 square feet; total heating surface 874 square feet, weight 21 tons 7 cwt. Experiments made upon this engine showed the smoke-box temperature to be about 600 deg. Fah., with the steam temperature at about 312 deg. (G. P. Bidder before the Gauge Commissioners, 1845). The steam temperature corresponds to a gauge pressure of about 65 lb.

In 1842 the long boiler was applied to 2–4–0 goods

and mixed traffic engines, also with inside cylinders and inside plate frames. These were built by Stephenson, Kitson, Longridge, and the Vulcan Foundry until 1846, though a few continued to be built by the first-named firm until 1860. Messrs. Stephenson supplied their drawings to other firms building the patent engines, and a 2–4–0 engine of Stephenson's early design built by Longridge, 1846, was illustrated in THE ENGINEER of January 21st, 1921, page 69. A North Midland engine, No. 71, of this type, built in October, 1842, by Stephenson, was the first locomotive to be fitted with link motion and three others for the same railway had Dodds's wedge motion. Drawings are given in Warren's book, pages 364 and 369.

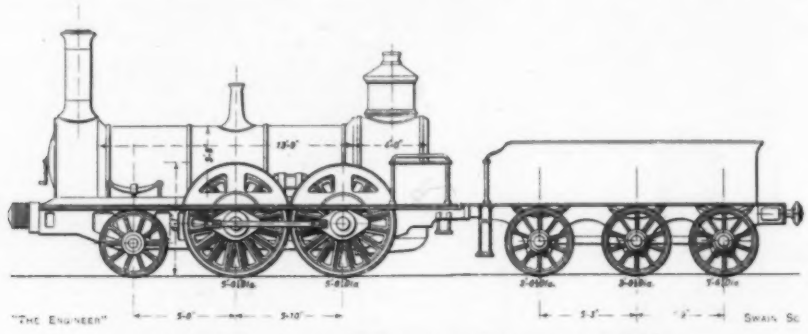


FIG. 48—BRISTOL AND BIRMINGHAM ENGINE—VULCAN FOUNDRY

Interesting examples were two passenger engines by the Vulcan Foundry, 1846, for the Birmingham and Bristol Railway—Fig. 48—with 5ft. 6½in. driving wheels, 16in. by 22in. cylinders, and 1117 square feet of heating surface. The deep inside solid plate frame, Stephenson's type of T iron wheels, the balance weights, and the inside framed tenders are features of special interest.

Before dealing with the six wheels coupled long boiler engines, the first of which came out in May, 1843, it is more convenient to complete the account of the 2–2–2 and 2–4–0 passenger engines. In 1844 Messrs. Stephenson constructed a new type of 2–2–2 engine with outside horizontal cylinders at the front—Fig. 49. As in the preceding engines, the bearings were inside and the driving wheels were without flanges. The first, built for the Norwich and Yarmouth Railway, had 5ft. 6in. driving wheels and 14in. by 22in. cylinders. Later engines of 1845 had 15in. by 22in. cylinders. A number were built to Stephenson's drawings for the Brighton, Croydon, and Dover Joint Committee by Nasmyth and Co. One of the class, White Horse of Kent, which figured conspicuously in the evidence given before the Gauge Commissioners, had a short wheel base of 10ft. 3¾in., boiler barrel 12ft. 6in., and fire-box casing 3ft. 8in. long. Total heating surface 893 square feet, of which the fire-box contributed 55 square feet. Grate area 9 square feet.

Although the design solved the boiler problem to some extent, the long overhang at each end introduced a serious defect from the standpoint of stability, more especially in the outside cylinder type, in which lateral swaying was very pronounced at speeds of over 35 miles per hour. This defect was aggravated by the lack of balance weights, for these earlier engines do not appear to have been provided with them. Messrs. Stephenson, therefore, introduced a third type of "long boiler" passenger engine in 1845, in which the driving axle was placed immediately in front of the fire-box, thereby allowing the outside cylinders to be placed further back towards the middle of the engine—Fig. 50. A number of these engines had large driving wheels 6ft. 6in. diameter, including the first of the type, which was built in October, 1845, for the Great North of England Railway, and was the engine A tested by the Gauge Commissioners. Warren (page 386) points out that the drawings for this engine were approved by R. Stephenson in April, 1845, and therefore that it was not intended, as implied by Sir Daniel Gooch, for the gauge experiments. This, and many built in 1846, retained the "Gothic" form of fire-box casing, but later engines, as in Fig. 50, which represents a Stephenson engine of 1847 with 6½ft. driving wheels for the L. and N.W.R. (Southern Division), had ordinary raised fire-boxes. Features common to all of them, as built by Stephenson, Jones and Potts, and Tayleur, were the flangeless middle pair of wheels and the long-forked connecting-rods.

The L. and N.W.R. 7ft. engines, the largest of the type, had 15in. by 24in. cylinders, 3ft. 10in. carrying wheels, and wheel base 13ft. Heating surface of tubes 875 square feet, of fire-box 64.4 square feet, total 939.4 square feet. Grate 11.45 square feet. Weight in working order 24 tons 4 cwt., of which 13 tons 1¼ cwt. were available for adhesion. Some of the Jones and Potts engines with 6ft. 6in. wheels had larger heating surface, 1023 square feet total, and weighed 25¼ tons, but their wheel base was only 12ft. The 13ft. base engines were the better, since those with 12ft. base were by no means steady at high speeds, and there were cases of derailment. Engines of this type were constructed until 1849 for British railways, but the last four were made by R. Stephenson and Co. in 1855 for Egypt, where they lasted on local trains until 1900–1902. They had 6ft. driving wheels, 14in. by 22in. cylinders, and the leading and middle springs were connected by compensating levers. Their British sisters had nearly all disappeared before 1870.

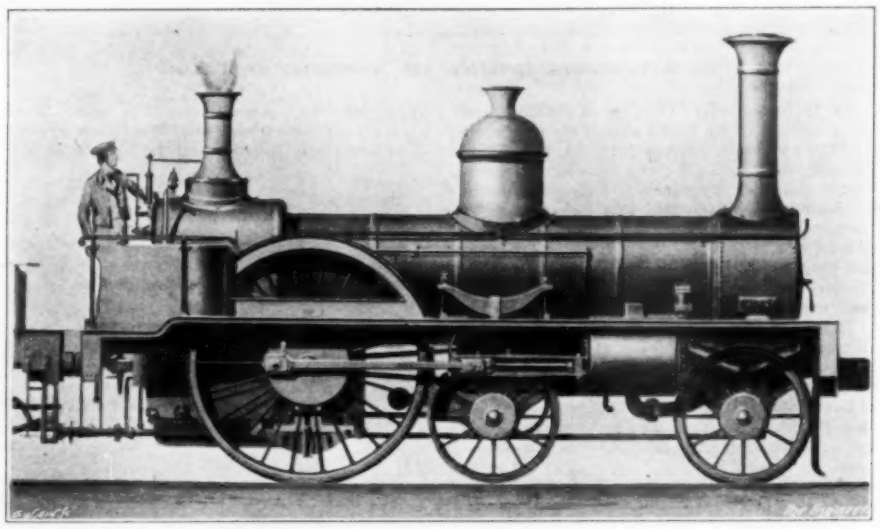


FIG. 50—L. AND N.W. ENGINE—R. STEPHENSON AND CO., 1847

The 2–4–0 type underwent similar changes in design, and during 1845–9 many were built with outside cylinders, and the usual long overhang at each end. The coupled wheels were generally 5ft. 6in. diameter, but a number on the York, Newcastle and Berwick and the Eastern Counties railways had 6ft. wheels. On the former line and on the York and North Midland Railway many subsequently had the 6ft. driving wheels removed, and 5ft. 2in. to 5ft. 6in. wheels substituted. The cylinders varied from 14in. and 15in. diameter by 22in. stroke to 15in. diameter by 24in. stroke. The driving wheels in all cases without flanges.

In spite of its defects for fast traffic, the type for a few years was much in demand and was built not only by Stephenson, but by Kitson, E. B. Wilson, Jones and Potts, B. Hick, Tayleur, Sharp Bros., and Gilkes, Wilson of Middlesbrough. Those by Sharp were chiefly exported to Germany, mostly with 4ft. 6in. coupled wheels for goods traffic. They were copied by Borsig and several other firms, and for many years remained the standard goods engines in that country.

There were also a few 2–4–0 passenger engines by Messrs. Stephenson, in which the cylinders were brought back to a position behind the leading axle, and the connecting-rods drove the trailing axle placed in front of the fire-box—Fig. 51.[2] This type appeared in 1848, though only a few examples ran in this country on the York, Newcastle and Berwick Railway. They were the prototypes of the later well-known French designs.

It cannot be said that the long boiler passenger engines were a success. The boilers were certainly more efficient than those with the very short tubes previously used, but this gain was offset by the unsteadiness of the engines, even to the extent of dangerous oscillation. The boilers themselves suffered in that the trailing overhang necessitated short fire-boxes and restricted grate areas. With small grates and long 1¾in. to 2in. tubes, small blast pipes were necessary, though many engines of that day, even with short boilers, suffered from these defects. Coke was the fuel used, and therefore the very small fire-

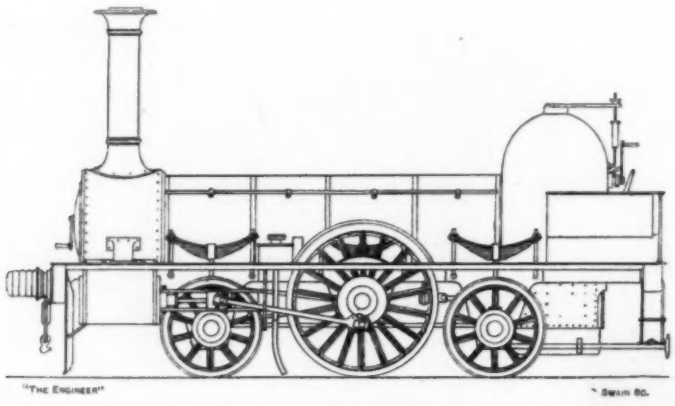


FIG. 49—STEPHENSON'S OUTSIDE CYLINDER LONG BOILER ENGINE

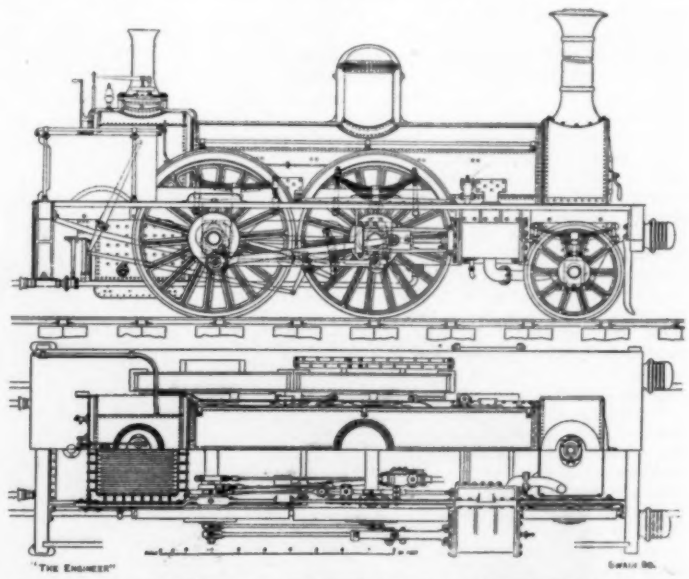


FIG. 51—YORK, NEWCASTLE AND BERWICK ENGINE—R. STEPHENSON & CO., 1848

[2] Fig. 51 is reproduced from Mr. Warren's book by special permission of R. Stephenson and Co., Limited.

box was practically possible, but would not have been so had coal been burnt. But in criticising the engines, other circumstances must be taken into consideration. The relation of wheel base to turntables has already been mentioned. There was also the important question of balancing, which was then but imperfectly understood. This subject will be mentioned subsequently, but it may be added that a few of the long boiler engines had part of the revolving masses balanced by extensions of the wheel bosses. There does not appear to have been any reciprocating balance, without which such engines were bound to behave badly at any but very moderate speeds. On one railway, the Eastern Counties, on which better methods of counterbalancing had been introduced by Fernihough, the long boiler engines generally appeared to give tolerable satisfaction, seeing that they remained in service on that line much longer than elsewhere. After about four years' service on the Midland, all the long boiler passenger engines were radically reconstructed with new frames, inside cylinders, and trailing axles behind the fire-box, only the boilers, cut down in length, being used again.

On the other hand, on certain French railways, such as the P.L.M. and Paris–Orleans, the long boiler 2–4–0 was for a long time the standard express engine, and many were built until 1873 with 6ft. 6in. coupled wheels and wheel base 13ft. 1in. long. French speeds at that time were considerably lower than those in this country; nevertheless, the use of such engines showed that proper balancing improved the type considerably. After 1873 they were gradually converted to the 2–4–2 type by the addition of a trailing axle behind the fire-box.

We are indebted to Mr. John Kitching for permission to reproduce the copyright photograph of a S. and D. locomotive of 1845—Fig. 42.

Institution of Mechanical Engineers.

Roller Bearings for Heavy Duty.

At an extra general meeting of the Institution of Mechanical Engineers, held in London last Friday, a paper, entitled "Anti-friction Bearing Applications for Heavy Duty," was presented by Mr. J. B. Dahlerus, of Luton. In effect, as may be seen from the abstract of the paper which we reprint elsewhere in this issue, the author was concerned solely with the applications of roller bearings. Chief interest centred round the author's remarks on the use of such bearings on railway rolling stock, but his paper also extended to a discussion of their employment on tramways, rolling mills, log frame saws, rope drives, calenders and other machinery. The attendance of members was on the poor side, and the discussion failed to reach a high level. Both facts may possibly be explained on the ground that, as previously announced, the paper is to be further discussed at the annual general meeting of the Institution, to be held in London on Friday of next week.

The President, Mr. W. H. Patchell, in proposing a vote of thanks to the author, remarked that many years ago he had used roller bearings for armatures weighing about 4 tons. There was a definite and considerable saving of starting current, but after the machines had been run up to full speed, the benefit of the bearings disappeared. The design of the bearings at that time was imperfect, and they speedily failed.

Mr. J. A. Hookham, North Staffordshire Section, London, Midland and Scottish Railway, replying to the President, intimated that he had had no experience with roller bearings in railway work.

Mr. David Bain reported that about 1896–7 he had tried on a North-Eastern Railway bogie carriage a set of roller bearings made by the Roller Bearing Company. The bearings consisted of ordinary cylindrical rollers fitted in a cage on the axle. After running six or eight months on a stopping train, the carriage was put into an express train. The rollers were found to get out of alignment with the axle, and to cause pits to develop on the seat. Eventually, they failed by crushing out the sides of the boxes. Before they failed, he had tested the bearings for starting effort and found the advantage was five or six to one in favour of the roller bearings, as against plain bearings. He held that roller bearings would confer little benefit on railway vehicles running long non-stop journeys, but that on underground and tramway systems with frequent stops, they must have some advantage. Dealing with the benefits experienced with roller bearings on continental railways, he suggested that the advantage experienced owed its origin to the inefficiency of the ordinary bearings, which the roller bearings were tested against. The ordinary bearings were probably too wide, and the lubrication was not as good as it should be. The Midland Railway bearings, against which roller bearings, as reported in the paper, showed to some disadvantage, were very carefully designed and were exceptionally well looked after. While, in general, he thought that there were possibilities in the roller bearing for railway work, he did not see how the much increased cost of fitting them was to be recovered.

Mr. L. St. L. Pendred recalled the statement of a railway authority that it cost as much to start a train from rest as to run it for 50 miles. If that were true, then, obviously, the use of roller bearings would pay on short-distance trains, such as suburban. He held that the author deserved the members' thanks for the frank and candid way in which he had dealt with the Derby results in his paper. Those results at first sight were astonishing to anyone who could recall the immense benefit experienced when ball bearings were first fitted to bicycles. Some years ago, he continued, he had had some correspondence with the author's colleague, the late Mr. A. W. Macaulay, regarding a phenomenon experienced in anti-friction bearings, and in other details. It was found that parts in contact under pressure could corrode even although there was no trace of moisture present. In ball bearings, it had been found that the inner sleeve might become corroded into position, and it was suggested that this phenomenon was produced by purely mechanical forces. Was dry corrosion still being met with in ball and roller bearings?

Mr. H. J. W. Oxlade wondered whether the author was correct in giving the price of a heavy roller bearing of the type described as £20. He thought it should be nearer £120. Proceeding, he referred to a new form of axle made in three pieces, and discussed its special features as they affected the application of roller bearings to it. The outside of an axle, he held, should be as hard as possible to resist wear, but this hard exterior should be combined with an interior capable of exibiting a high resistance to fatigue. It was not easy, he said, to combine these two characteristics in one axle made in the ordinary way, but the three-part axle to which he had referred could, he claimed, readily be made to secure that end. It was even possible, he thought, that with it the outside of the journal could be made to serve as the race for the ball bearing.

Mr. Henry C. Jenkins, dealing with the phenomenon of dry corrosion to which Mr. Pendred had referred, suggested that it might be due to lack of homogeneity in the material. Slight differences in composition would cause the metal to react electrically in the presence of moisture, carbon dioxide, &c., in the atmosphere, and so set up corrosion. If flow occurred on the surface the metal became burnished and acquired a homogeneous skin that would stop "dry" corrosion. But if alternating stress acted on the metal, burnishing did not take place. It followed, therefore, that if in a bearing there was a slight difference of fit, the alternating stresses set up would destroy the burnished skin and corrosion could start between particles at slightly different electrical potentials.

Mr. C. E. Davies said that he had collaborated with the author's firm in fitting roller bearings to cold strip rolling mills. The power lost in the bearings of rolling mills as ordinarily constructed was, he said, very great. The bearings could not be properly lubricated, and as much as 90 per cent. of the total power might be lost in them. In such circumstances the use of roller bearings produced, as the author showed, a very large saving of power. The modern tendency towards the use of higher rolling speeds accentuated the advantages of employing roller bearings. The four directions in which benefit accrued from their use were:—(*a*) A saving of power amounting to from 30 to 50 per cent.; (*b*) the elimination of heating in the bearings; (*c*) a gain in accuracy of the roll product; and (*d*) an economy of lubricant. It was at present difficult to foretell what the life of a roller bearing in a rolling mill would be, but he was satisfied that it would be reasonably long. As regarded cost, the increased expenditure involved in fitting a new mill with roller bearings would be partially off-set by the economy effected by the use of lighter gearing and smaller motors. A difficulty was undoubtedly introduced by the fact that the roller bearing had to be smaller than the standard roll bearing. In this connection he was interested to learn from Mr. Dahlerus that on the Continent hot rolls were now being made, for the sake of strength in the bearings, with a steel centre and a chilled cast iron exterior. Replying to a question addressed to him by Mr. Patchell, Mr. Davies stated that so far he had had experience with ball bearings only on continuous rolling mills. He admitted that reversing mills presented a different aspect, but he would have no hesitation in recommending the use of roller bearings in such mills.

Mr. L. A. Legros recalled his experience with roller bearings of an early type when applied to tramway work. The rollers in those bearings, he said, were about ⅝in. in diameter by 4in. to 4½in. in length, and were enclosed within a gun-metal case. The rollers, as in Mr. Bain's experience, tended strongly to lose their alignment with the axle, and failure ultimately arose by the journals of the axle wearing into a conical form. He did not get more than 10,000 miles from any one of the bearings. When they failed, they failed suddenly, the conical wearing of the journals being developed within the last four or five miles.

Mr. T. W. Cooper criticised the author's specification of the desiderata of a good roller bearing. It was, he held, very controversial whether the bearing should be capable of dealing with both radial and thrust loads and whether it ought to be able to deal with thrust load in either direction. The property of self-alignment was sometimes advantageous, but it was not always essential. The author's criticism of the sleeve type of roller bearing for tramway axles was, he held, a little misleading. Quite a number of bearings of that pattern had been fitted and had been running satisfactorily for three or four years without the slightest sign of trouble. It was not the design of the bearing that proved unsatisfactory but the method of locking the sleeve to the axle. As regarded the saving of 11.62 per cent. in the electrical energy recorded for the Glasgow car test, corresponding figures at Wigan and on an L.C.C. car were 25.5 per cent. and 28.5 per cent. respectively.

Mr. S. G. Williams remarked that roller bearings had been greatly improved with respect to the properties of the materials used in their construction. To-day a high carbon high chromium steel hardened right out was used instead of a simple case-hardened steel. Improvements, too, of great importance had been effected in the inspection, organisation, and other features of the workshop processes involved in the manufacture of the bearings. If the railways ever decided to take up the use of roller bearings on an extensive scale they could at once dismiss the idea of making them themselves.

Mr. W. F. Cully asked the author to enlighten users on the facts observed when roller bearings were about to fail. What signs were to be looked for as indicating approaching failure? In connection with the use of large roller bearings on rolling mills, did any trouble arise from the well-known instability of shape characteristic of hardened steel?

Professor P. N. Baker asked whether the provision of any requisite end shape gave trouble in roller bearings. Captain H. R. Sankey recalled some early experiences with roller bearings on a Willans engine. Mr. B. G. Spittle suggested that there were other types of anti-friction bearings beyond that dealt with by the author.

Mr. Dahlerus, replying to the discussion, said that for the moment he was not at liberty to disclose certain figures he had obtained from some of the railway companies regarding the number of hot bearings discovered each year, but he could say that no railway on the Continent or in the United States had a record in this respect approaching the freedom recorded by the Midland Railway. In contrasting the Midland and the continental and American results it had to be remembered that the weights of the coaches were very different. In this country a 30-ton coach was carried on eight axle-boxes, while abroad the same number of boxes would be used to support 60 tons. As an example of the benefit that might on occasion be conferred by the adoption of roller bearings he mentioned a small railway owning a level line. The trains usually consisted of twelve coaches each, but the time came when it was desired to use fifteen-coach trains. A new engine equipment to provide the increased power would have necessitated the strengthening and rebuilding of seven bridges. But as the line was level the existing engines were deficient only in starting effort, and were adequate to haul fifteen-coach trains once speed had been got up. The situation was completely met by fitting the coaches throughout with roller bearings. The possibility of reducing starting resistance could thus be a most valuable practical feature favouring the adoption of roller bearings. In America the Pennsylvania Railway had fitted roller bearings to some of its coaches, not with the object of reducing starting resistance, but to overcome the tendency of the boxes to run hot. Since the roller bearings were fitted three years ago no trouble of this kind had been experienced. He agreed with Mr. Williams regarding the very great importance to be attached to the choice of material for the manufacture of anti-friction bearings. All the processes through which the material passed, from the ore upwards and the quality of the workmanship upon it in all its stages, required full and correct control. Without such control it was impossible to ensure that the bearings would give satisfaction.

Electric Forces and Quanta.*

By J. H. JEANS.

It is just about twenty-five years since Lord Kelvin spoke of "two clouds" obscuring "the beauty and clearness of the dynamical theory which asserts light and heat to be two modes of motion." The clouds which Lord Kelvin saw as clouds no bigger than a man's hand have grown until they have almost filled the firmament; little can now be seen of the beauty and clearness of the dynamical theory of which Lord Kelvin spoke. The old dynamical theory has given place to the new theories of relativity and of quanta; what Lord Kelvin thought were transient clouds shortly to melt away have proved to be new theories in process of growth. The "beauty and clearness" he saw under these clouds was mostly a mirage. I have chosen as my title "Electric Forces and Quanta," the two halves of this title corresponding roughly to the two new theories, and I propose to try and sketch out for you the changes these theories have introduced into our conception of fundamental electrical processes. Let us consider electric forces first. Lord Kelvin, following Maxwell and Faraday, regarded an electric force as evidence of a stress in the ether. An ether can transmit two

* Sixteenth Kelvin Lecture, delivered before the Institution of Electrical Engineers on February 5th. Abstract.

kinds of stress, one arising from a state of static strain and the other from a transfer of momentum. These were supposed to be electric and magnetic forces respectively. Nevertheless, the conception involved a difficulty which seems to have troubled the nineteenth century physicists not a little. The energy of the ether could represent all kinds of electro-magnetic energy, but could represent nothing else. Gravitational energy, for instance, could not be interpreted as ethereal energy, for the only two types of energy which the ether could hold were already allotted to electric and magnetic energy respectively, and in time it became clear that the only thoroughly satisfactory possibility was no ether at all. First the development of the theory of relativity gave its death blow to the old luminiferous ether of Lord Kelvin, Maxwell and Faraday. The main result of this theory can be stated in the form that all the phenomena of Nature go on precisely as though there were no ether. This does not, of course, abolish the ether; it shows the conception of an ether to be superfluous and perhaps even a little bit ridiculous—for it is ridiculous to fill the whole of space with a medium and then agree that everything goes on just as if the medium were not there—but it does not show it to be illogical. To the question "Does an ether exist?" science is still unable to give a definite answer. The question "Does the ether exist?"—if the ether is taken to mean the luminiferous ether of Maxwell and Faraday, ought almost certainly to be answered in the negative.

We may be confident that if an ether exists it must be something very different from the Maxwell-Faraday ether. It must probably be thought of as a four-dimensional structure and must be more subjective than the Maxwell-Faraday ether. Each of us must carry his own ether about with him, extending through all space and all time, much as, in a shower of rain, each observer carries his own rainbow about with him. Whether such a structure, if it exists, ought to be called an ether, others must decide.

The paper which practically abolished the ether as a serious scientific hypothesis was published by Einstein in 1905. Ten years later he published a second paper which may be said to have shown us how to get on without either an ether or action at a distance. His first paper, as subsequently interpreted by Minkowski, had shown that all the phenomena of electro-magnetism might be thought of as occurring in a continuum of four dimensions—three dimensions of space and one of time—*in which it is impossible to separate the space from the time in any absolute manner. You* may separate them in one way, but you will find that *I* separate them differently, and in the end we shall both agree that no objective separation is possible. Einstein's second paper showed that the phenomena of gravitation could be explained on the supposition that the geometry of this four-dimensional continuum was not of the ordinary Euclidean type. The continuum was supposed to be affected by kinks and twists in the neighbourhood of gravitating masses, and it was these, and not a "gravitational force," that threw a particle out of a straight course. It became just as inaccurate to say that the sun attracts the earth as to say that a bowl on an uneven bowling green is attracted or repelled by the other bowls. In this curved space, the path of a particle is always a geodesic—the most direct distance between two points—and this may have very different properties from a Euclidean straight line. We must, of course, remember that the paths we are discussing are in a four-dimensional space. If we were speaking of ordinary paths in three-dimensional space it would clearly be ridiculous to say that the curved orbit of a planet provided the most direct path from perihelion to aphelion; it is only when we allow for the motion in time as well as in space that the statement becomes reasonable. We can get rid of most of the motion in time by supposing our planet, or other body, to move with enormously high velocity, and then the path described actually approximates to a straight line, which is now the most direct path even in three-dimensional space.

We can gain some conception of the main features of Einstein's geometry from the analogy of spherical geometry; the curved surface of our earth provides a fair two-dimensional analogy to Einstein's curved four-dimensional space. To one who thinks in terms of parallels of latitude and longitude the most direct course on our earth's surface looks oddly curved; it is always a surprise to the unsophisticated traveller that the ship taking him from Southampton to New York turns a bit to the north on rounding the Lizard. And the great circle course on the ship's chart looks very much as if the ship were describing an orbit about a centre of attraction in the middle of the Sahara.

If Einstein was able to avoid the evils both of action at a distance and of an ether in the gravitational problem, there would seem to be no reason why they should not be similarly avoided in the electro-magnetic problem which specially interests us to-night. Not only is there no reason why this should not be done; it actually has been done. In 1918 Weyl pointed out that the geometry of Einstein was not the most general geometry which conformed to the relativity condition. Space could be distorted still further in ways unimagined by Einstein; these further distortions of the four-dimensional space being specified by the six components of a vector. Now the significant thing is this. On calculating the relations which must hold between the six components of the vector in order that the relativity condition may be satisfied, Weyl finds equations which are precisely identical with the electro-magnetic equations of Maxwell, the six components in question now appearing as the three components of electric force and the three components of magnetic force.

It is not easy to explain in non-mathematical language what is the essential difference between Weyl's space and the old Euclidean space. We can best attempt it by treating Einstein's space as a half-way house. Returning for a moment to the two-dimensional analogy provided by the earth's curved surface, we know that the length of a degree of longitude decreases as we recede from the equator; the ship turns north on its voyage from the Lizard to New York in order to take advantage of the shorter degrees of longitude up north. The planet going round the sun describes a curved path for a similar reason. According to Einstein's theory a measuring rod changes in length as it moves about in a gravitational field—a 2ft. rule is no longer 2ft. in length if taken from the earth to the sun—it is because of this that the wave length of the light represented by a definite spectral line when emitted at the sun's surface is different from that of the same light emitted on earth. The length of the rod depends only on its distance from the sun, but in Weyl's space the length of such a rod does not depend solely on its position; it depends also on the path by which this position has been attained.

When Einstein explained gravitation in terms of curvatures and special metric properties of space, the equations of his theory were found to be different from those of the old Newtonian theory. It was accordingly possible to make an observational test between the two theories, and this decided immediately and conclusively in favour of the theory of Einstein. There is no hope of establishing the truth of Weyl's theory in a similar way, for the equations to which it leads are precisely identical with the already universally accepted equations of Maxwell. Weyl's theory can only be judged by its inherent plausibility or the reverse.

Judged by this standard, everything seems to be in its favour. The luminiferous ether failed partly because it left no room for gravitation, partly because its mechanism had to be supposed to be too elaborate for the facts to be explained. The hypothesis of an ether led us to anticipate a whole series of different phenomena corresponding to different velocities through the ether, so that when these were not forthcoming its advocates were compelled to elaborate a complicated theory by which all the forces of Nature were in collusion to make all these different phenomena appear the same to us. The Einstein-Weyl geometrical theory escapes both these reproaches. Both gravitation and electro-magnetism fit perfectly naturally into their places. These two systems of forces correspond exactly and completely to the ways in which a four-dimensional geometry can differ from the simple geometry of Euclid. The observed forces of gravitation and electro-magnetism correspond exactly to the most general forces which are possible, if "force" is interpreted simply as an illusion arising from a crumpling up of space. Consequently the observed phenomena of Nature are precisely those which ought to be observed—not one is missing and neither is there room for a single one more. There is now no collusion among the forces of Nature to conceal a whole series of unobserved phenomena; indeed, there could be no concealment, because there is nothing to conceal. By its simplicity, its completeness and its perfect agreement with the observed phenomena of Nature, the theory seems likely to take its place as our final interpretation of the "forces" of Nature.

We now see that the universe of Euclid, in which parallel lines never meet and in which two sides of a triangle are always greater than the third, was a simplified ideal universe. In the same way the universe of Aristotle and Plato, in which space and time are permanently distinct and essentially different in their natures, was a simplified ideal universe. Both universes were too simple to fit the facts; remove the unwarranted simplifications and we are left with a universe whose geometrical properties are expressed by such equations as Einstein's gravitational equations (to which Newton's inverse square law gives a good approximation) and Maxwell's electro-dynamical equations. Thus geometry, cleared of *all* unjustifiable assumptions, transforms itself into mechanics, both gravitational and electro-dynamical. A being who was born without any one of his five senses, but with unlimited geometrical reasoning powers, could deduce the general nature of the actual world without any experience of reality; he would anticipate that landslides, earthquakes, thunderstorms and auroræ would occur; but he would know nothing about "forces" and would regard these phenomena merely as geometrical necessities.

But although generalised geometry can predict and explain all the systems of forces of the universe, it has its limitations; there are features of the actual universe before which it stands powerless. Nothing in geometry can explain the essential difference between positive and negative electricity, or the atomicity of electric charges, so that the whole inner structure of matter, including the whole of chemistry, would be outside the scope of the intuitions of our supposed geometer.

Electric charges are a consequence of, or at least are associated with, a curving or crumpling of space, but so far as pure geometry goes there is no restriction in the extent of this crumpling, so that our geometer, reasoning from geometry alone, might expect to find charges of all possible amounts, whereas in actual fact electric charges occur only in multiples of a definite unit, the charge of an electron. It is clear, then, that there is something more than geometry underlying the phenomena of Nature; the whole phenomenal universe may be geometry with restrictions if we like, but not merely the geometry which is obtained by generalising the geometry of Euclid until we can generalise no further. Space can be crumpled up qualitatively in all the ways known to geometry, but not quantitatively; the uniformity of electronic charge must in some way represent an absolute restriction on the measure of the crumpling.

Each particle of matter—each electron, let us say—occupies one point of space at any one instant of time, and the succession of these points will form a line in the four-dimensional space-time continuum—the "world-line" of the electron. In the neighbourhood of this world-line there is a deformation of space due to the existence of the electron.

The near approach of two electrons or of any two charged particles is represented by a near approach of their world-lines in the four-dimensional continuum. Each world-line is surrounded by its associated deformation, and in regions in which the world-lines are near to one another the adjacent regions of the continuum will be doubly deformed.

A priori there are two possibilities open. The first is that the two deformations are merely additive, just as when two ships approach each making its own wash (or deformation of the surface of the sea), the height of wash at any point is the sum of the heights of the washes made by the two ships independently. The second possibility is that, as there have been found to be restrictions on the amount of deformation associated with the two separate world-lines, there may be a further restriction on the deformation arising from their combination.

In actual fact the former alternative appears to prevail when one or both of the charged particles are "free" electrons, but the latter alternative when they are "bound" together—*i.e.*, when they are permanently describing orbits about one another. It is these latter restrictions that have given rise to the theory of quanta.

We can perhaps best visualise the inner nature of the quantum restrictions by going back to the analogy of the two ships making a combined wash which is in some way restricted to being of a certain height. We have supposed each wash individually to be restricted; if the velocity of the ships is fixed, this requires that each ship shall be of a definite size (corresponding to each electron having a definite charge). How can we now put a further restriction on the total wash of the two ships at points where their washes overlap? Only, I think, by keeping the ships at a specified distance apart. At any rate this is the way in which the quantum restrictions work. According to the Maxwellian electro-dynamics, an electron describing an orbit of any kind must necessarily radiate energy. We can calculate the rate at which energy ought to be radiated by the electron in the normal hydrogen atom; it is 0.46 ergs. a second. The resulting loss of energy would be compensated by a decrease in the radius of the orbit; we find that the rate of this decrease would be about 112 cm. a second, so that the atom ought to disappear altogether within a small fraction of a millionth of a second. Thus it is the quantum restrictions which give a permanent existence to matter.

Here, then, we have a case where the requirements of Maxwell's theory and those of the quantum theory are in irreconcilable conflict. It is the quantum theory which carries the day. Somewhere before we reach the most minute of all structures, Maxwell's theory fails and the quantum theory takes its place. In terms of space curvatures we may say that Maxwell's theory is represented by a continuous curvature or crumpling such as might be applied to a rubber membrane, while possibly the quantum theory may be represented by a so-to-speak "jerky" deformation, which is the best that can be done with a scaly surface such as a crocodile skin. If we wish to cover the earth's surface with a membrane, it makes little difference, from the point of view of closeness of fit, whether we select rubber membrane or crocodile skin, but it makes all the difference if we are manufacturing a pair of gloves. The quantum theory represents, perhaps, a quality of space which is somehow analogous to scaliness in a skin.

The quantum theory has been less successful in discovering the nature of radiation, although even here it has been beyond comparison more successful than any previous theory. To illustrate the difficulties of the problem, let us consider one single phenomenon—the X-ray photo-electric effect. A thin stream of electrons each moving with a same high velocity is allowed to impinge on a material target, and X-rays are emitted which carry off the energy destroyed by the collision. These X-rays pass through a gas, and it is found that as soon as the process starts atoms are ionised and shoot off electrons with a velocity equal to that of the original stream of electrons. Even if

the density of X-radiation is so slight that according to the old view of radiation an atom would take years to absorb the energy necessary for ionisation, nevertheless ionisation is found to begin at once, energy being absorbed which is not only sufficient for mere ionisation, but suffices in addition to endow the ejected electron with high velocity.

Such a phenomenon is, of course, totally inexplicable in terms of the luminiferous ether, or even in terms of Maxwell's equations. The quantum theory gives only a partial explanation.

Einstein at one time suggested that radiant energy was hurled through space tied up in indivisible packets like bullets from a rifle, but it has proved quite impossible to reconcile this suggestion with the optical phenomena of interference. A more recent hypothesis, also due to Einstein, calls for a revision of our conception of the action of an electric field on an electron. This new conception explains the otherwise incomprehensible photo-electric effect as well as other puzzles in the behaviour of radiation. The difference between a strong and a weak electric field acting on an electron is no longer that the strong field produces a big change of velocity and the weak field a small one; it is that the strong field has a big chance of producing a change, and the weak field only a small chance of producing the same change. When radiation acts on a body containing a great number of electrons the final result is the same on the new theory as on the old. But there is a difference of method which is similar to the difference in propulsion between a motor car and a steam engine; on the new theory the charged body is propelled by a succession of little kicks, whereas on the old theory it was propelled by a steady pressure.

I have tried to sketch, in the short hour at my disposal, the outlines of the changes which the past quarter century has introduced into our conception of the nature of electric forces and of the electromagnetic field. You will agree with me that there have been giants at work in the field of pure electrical energy. When the history of science comes to be finally written, the quarter century we have just lived through will, so far as we can now judge, stand out as the period in which man first began to understand the true nature of electricity.

Obituary.

OLIVER HEAVISIDE.

By the death of Oliver Heaviside, which occurred on Wednesday, February 4th, a very remarkable man has been removed from the scientific world. For many years his work did not receive the recognition it deserved, a fact which he seems to have felt somewhat acutely, and which was perhaps responsible for his long absence from all scientific gatherings. He was born in May, 1850, and for some years was in the employment of the Great Northern Telegraph Company at Newcastle-on-Tyne, but after 1874 he retired and settled down in Devonshire, where he devoted himself to the study of electrical problems. He lived for a considerable time the life of a recluse, although in the early days he was a prolific writer of scientific articles and papers, which, for the most part, practical men failed to understand. Great as the work of Heaviside was, it is not improbable that up to the year 1922 many engineers had almost forgotten him, but in that year the Institution of Electrical Engineers' Commemoration meetings were held, and Heaviside's achievements were once again brought into the limelight. It was Sir Oliver Lodge who drew attention to the great service which Heaviside had rendered to the electrical industry, and who suggested that the Institution should send him a message on that auspicious occasion, a suggestion which was immediately put into effect.

One of Heaviside's most notable achievements was that of pointing out the importance of self-induction in communication cables. It took him a long time to convince the early electrical workers, and especially the telegraph engineers, to pay any attention to what he said, and Sir William Preece was very annoyed with him for his interference. Lord Kelvin's work on cables took into account capacity and resistance, but ignored self-induction, which Heaviside showed would partly neutralise capacity, which, together with resistance, distorted the signals. Heaviside did not, however, put his idea into practice. It was Pupin in America who gave to the world the exact method of adding induction to communication circuits, by the invention of his loading coils, but as Pupin and as everyone else who has studied the subject admits, Heaviside provided all the information, except the last arithmetical details, and he gave it to the world without attempting to protect it, as he might have done.

The work of Heaviside was in advance of his time, but it has since borne fruit in the hands of practical electrical engineers. He was a genius of an extraordinary type, and his ideas were often beyond the understanding of others who sometimes regarded him as a nuisance, rather than a help.

Mathematicians are very apt to become unpopular in practical engineering circles, and if they introduce entirely new mathematical methods of their own, as Heaviside did, they are almost sure to become so. Oliver Heaviside's work consisted in a large measure in introducing Clerk Maxwell's theory to those who were not skilled in the mathematical methods which Maxwell used. In this connection, he introduced a vector algebra, which, as Dr. Eccles explained at the Commemoration meetings of the Institution of Electrical Engineers, seemed simpler to him than the ordinary classical mathematical methods. But, unfortunately, the orthodox mathematicians at the time found the new method much more difficult than the one they already understood, and they rejected it. Heaviside's work was not therefore studied in our schools as it might otherwise have been, but other countries apparently viewed his ideas rather more favourably. At any rate, Lorentz, who is responsible for much of the theory of the electron and its relation to matter, adopted Heaviside's methods at an early stage, and in these days even the pure mathematicians who write books on the Einstein theory employ Heaviside's system. Here, again, however, Heaviside's work was in advance of his time, and by introducing his vector algebra he prevented many from understanding his ideas who might otherwise have done so. But he also explained a great many facts in words, and there is much to be learnt from his writings.

In the field of radio communication Oliver Heaviside also did useful work. When Mr. Marconi was carrying out his early experiments, it was thought by many that it would be quite impossible to transmit messages over long distances, as, for example, as between England and Canada, because the waves would shoot off into space, but Heaviside pointed out that in all probability the upper atmosphere was permanently ionised, and in that case the waves would be compelled to pass between two spherical surfaces—the ionised layer and the earth. Although it is still an unsettled point as to whether the layer exists or not, a good many eminent men believe that it does, and to this day great importance is attached to Mr. Heaviside's theory. In fact, the theory has been used to explain many things which wireless experts do not understand.

Although Oliver Heaviside is said to have complained bitterly of the way in which his work was received, the message to him which was drafted at one of the Commemoration meetings of the Institution of Electrical Engineers should have assured the great physicist that in 1922 at any rate engineers were fully alive to the value of his labours. This message, which sums up his work remarkably well, was agreed to on February 23rd, 1922, and it read as follows:—"The members of the Institution of Electrical Engineers, assembled at the Commemoration meetings now being held to celebrate the fiftieth anniversary of the first meeting of the Society of Telegraph Engineers (now the Institution of Electrical Engineers), with their thoughts directed to all those who in earlier days laid the foundations of the science and industry which the Institution represents, desire to send a message of greeting and remembrance to Mr. Oliver Heaviside, F.R.S., honorary member of the Institution. In the course of the meetings they have been again reminded of, and have recognised the great importance of the classic work achieved by Mr. O. Heaviside, and published by him in his papers and writings from 1887 onwards, and especially of his discovery of the importance of inductance in circuits for the transmission of telegraphic and telephonic signals without distortion, and of him as the originator of the methods now being universally applied for this purpose, and in no less measure of his investigations and discoveries relative to the propagation of electromagnetic waves in space, the results of which are now being utilised in wireless or space telegraphy and telephony. They are convinced that, as now, so in the future will the name of Heaviside rank among those of the great founders of the science of applied electricity."

Oliver Heaviside was made the recipient of the first Faraday Medal, which was presented to him at his home in Torquay by Mr. J. S. Highfield, who at that time was President of the Institution. Heaviside's earlier scientific contributions were collected into two volumes of "Electrical Papers" (1892), and his later work is in three volumes, entitled "Electromagnetic Theory," published in 1893, 1899 and 1912, and reprinted in 1922. He was elected a Fellow of the Royal Society in 1891. He was also Hon. Ph.D., of Göttingen, and an honorary member of the American Academy of Arts and Sciences.

Literature.

The Principles of Applied Electro-chemistry. By A. J. Allmand and H. J. T. Ellingham. Second edition. London: Arnold and Co. Price 35s. net.

The subject of this book has not been treated very often in this country in a systematic scientific way. Handbooks for electro-platers there are, and works on electric furnaces, &c., but most of the information necessary to the worker is spread about in various "Transactions" and *Journals*, the patent literature not to be forgotten. The book under review is a laudable attempt to condense a vast subject into one fairly handy volume. Some 200 pages are given to the scientific principles of the subject, and the rest to practical applications. It would probably have been better if the authors had made two distinct companion volumes of Part I. and Part II. respectively. In the Preface of this edition Allmand seems to be aware of this, and makes an apology for the contraction of Part I. to allow for the expansion of Part II. As it stands, Part I. is unusually clear and concise, and characterised by a laudable simplicity of treatment. There is, however, the usual appearance of an attempt to reform the accepted terminology, which seems to be affected by modern writers on kindred subjects. Take, for instance, "Electronic and Electrolytic Conductors," which is given as a heading in Chapter II. Logically it should be "Electronic and Ionic Conductors," but why not stick to what the authors give later on—"metallic (or electronic) and electrolytic conductors"—excluding electronic altogether? The older writers did not speak about ether conductivity or the like. Similarly, why call a voltmeter a coulometer? It is just the same as calling glycerine pentane-triol, which has been proposed and abandoned. We are too matter-of-fact nowadays to be affected, and some of us are not so certain that the resurrected electron theory has come to stay. A minor point in connection with Part I. is the foreign appearance of some of the illustrations, which depict a galvanometer more like a gas meter or a mantelpiece clock than galvanometers as we generally see them. There is also distinct evidence of drawing too much on already existing publications; but, of course, that is not altogether avoidable.

In treating the dissociation theory, the authors perpetuate the notion that Arrhenius formulated this theory in 1887, a favourite German idea, mainly advanced to subordinate the subject under Van t' Hoff's theory of osmotic pressure. As a matter of fact, Arrhenius published his theory in June, 1883, in a dissertation presented to the Swedish Academy of Science, called "Recherches sur la Conductibilité Galvanique des Electrolytes." A *résumé* of this paper appears in the report of the British Association meeting of 1886 from the pen of Sir Oliver Lodge. Apart from calling the dissociation constant "activity coefficient," Arrhenius gave the whole thing to the world then. The further generalisation of 1887 embraced Van t'Hoff's notions as applied to electrolytes. In as far as practical electro-chemistry is concerned, the influence of the modern theoretical notions, including those of Ostwald, Nernst, Planck, &c., has yet to be discovered. Kelvin's and Helmholz's work regarding actual decomposition voltages is about the limit of theory actually of assistance to the practical man.

At the very end of Part I. one finds perhaps the most important innovation in choice of subject matter. The authors discuss the power factor ($\cos \varphi$) in working with alternating-current furnaces, a thing about which most chemists are ignorant. If they had also pointed out the folly of regulating the output of transformers in the secondary winding, they would have added another leaf to their laurels. On that subject chemists favour a transformer which uses more energy in the primary the less there is used in the secondary. It ought also to have been emphasised that the watt meter ought to be used by preference for controlling alternating-current furnaces, as is actually done where merely practical men direct operations.

Part II. appears to the reviewer a bit too contracted even after its expansion. Chapter I. of the section (XIII.) on primary batteries passes over the modern dry cells rather too quickly, considering that they are the subject of the only actual industry in that line. The secondary batteries do not fare much better. As an extraordinary omission, it may be pointed out that the authors describe "the famous chloride positive" without pointing out that there was originally a chloride positive invented by Laurent Cély, which was actually made with chloride of lead as a basis of manufacture, whereas the "famous" one is no "chloride" plate at all, and was invented by the Chloride Company's chemist in 1895. The literary references given seem, however, to date back to 1900, only covering a period of stagnation in practical electro-chemistry compared with the preceding twenty years. After the chapter on batteries follows one on "wet" electro-metallurgy and electro-plating. This part is on the orthodox lines and there is very little to say about it. With regard to bullion refining, the advantages are discussed, but not the disadvantages, apart from what might be inferred. Gold refining is, for instance, possible only where a continuous supply of crude bullion is available, as the capital sunk in solutions, &c., is very great. The chlorine and alkali industries get a fair modicum of space, but the possible extension of uses for chlorine gets two pages only! Various special processes for oxygen and hydrogen production, bromine, perchlorates, &c. &c. are given their share, and then follow descriptions of processes with fused electrolyte, all treated with due regard to limited space.

Thermo-electric processes and furnace constructions are given a fair prominence. One looks, however, in vain for the resistance furnace with a reverberating refractory ring filled with pieces of graphite, now used for melting refined silver to avoid losses by volatilisation. Carbide, silicon compounds, cyanamides, &c. &c., are all discussed, and the book finishes with descriptions of the fixation of nitrogen and ozone.

As a general review of a vast subject, the book is

excellent, but as a text-book for a worker on the subject, it is from obvious reasons insufficient. That practically all the inventions described are much older that the literary references would lead anybody to believe, is probably a characteristic of the desire of modern man to forget the past, and places the authors as being up to date. The appearance of a second edition is, however, proof enough that the conception of this book is fundamentally one which fills a gap in the scientific literature, and hence the authors are to be congratulated. It may even be the nucleus of a coming standard work on the subject.

The Internal Combustion Boiler.*

ALL designs of boilers are based on the principle of bringing the flame of the fuel into the closest possible contact with the water in the boiler. If this is one of the main ideas why not burn the flame inside the water? Is it possible to burn a flame in immediate contact with a liquid? It is, as every kind of liquid fuel burns in the liquid as long as the quantity of air or oxygen is large enough to ensure complete combustion. This idea is fully demonstrated in the working of the internal-combustion boiler, the principle of which is to maintain a flame burning in the liquid in order to evaporate the latter. During the years of experimenting, liquid hydrocarbons of a specific gravity between .8 and 1.2 have been used. Tar oil from Belgium, coal tar from Germany, Astatki from Baku, waste oil from America, and different kinds of oil from every part of the world have been tried. More than sixty different kinds of oil have been tried, and all could be burnt without difficulty.

The fuel crude oil, &c., and the air which is necessary for the combustion are supplied to the burner under a pressure which barely exceeds the pressure of the steam. The temperature in the centre of the flame is approximately 1800 deg. Cent. This temperature diminishes to the periphery of the flame, so that between the centre of the flame and the periphery a rapid fall of temperature takes place. Since a permanent stream of burning gas has to pass this fall of temperature, it is evident that also the last traces of carbon-monoxide must be converted into carbonic acid. In leading the combustion in such a way the possibility is ensured of burning the fuel more completely than in the open air. The combustion under pressure brings the molecules of the fuel into better contact with the oxygen, therefore under pressure and in water the most complete combustion can be obtained.

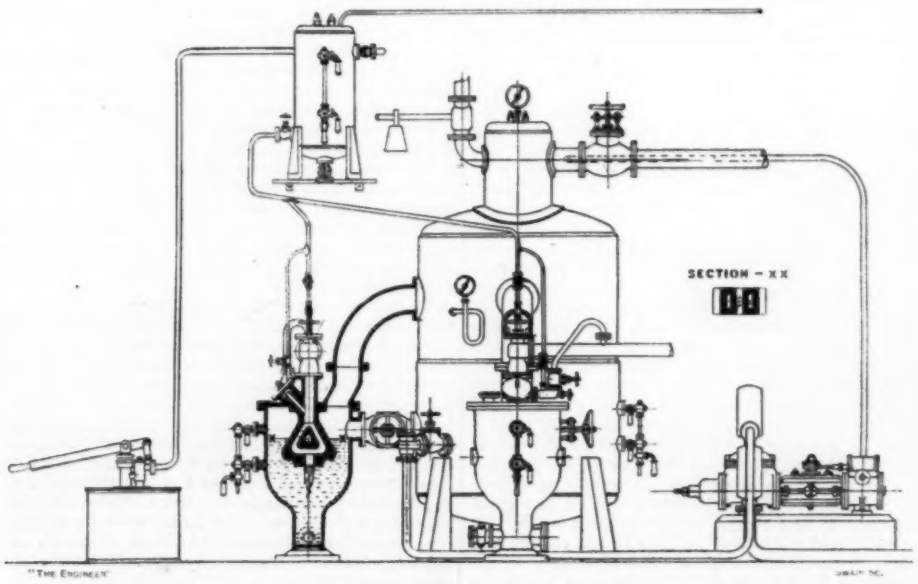
The mixture of gases which pass from the steam generator to the steam reservoir contains 60 per cent. of steam, and 40 per cent. of gases. These are the same gases which work in gas and oil engines, the only difference being that in such engines the amount of steam is much less.

The presence of this great quantity of gas in the steam makes the condensing engine impossible; *i.e.*, the exhaust steam can be condensed, and as feed water be pumped into the boiler, but a vacuum cannot be used because vacuum pumps of a very large size would be required. But this fact is not a serious disadvantage. The main idea is to save as much fuel as possible, and to obtain the highest efficiency. If this is possible without condensation all the better. Instead of the condenser we have an air compressor, which takes less space and needs less repairs than the condensation plant.

Practically every engineer and scientist maintains that the determination of the calorific value of any fuel, whether liquid, solid or gaseous, is exact, if we determine it either in the bomb, or calculate it by means of the chemical analysis. However, when we have to deal with the combustion of fuels or explosives we have sometimes to face riddles for which we have no explanation, since they are absolutely opposed to our knowledge regarding the heat theory and to the energy produced by the combustion according to our established formulas. I am of the opinion that under certain conditions which are still unknown to us electric vibrations produced during the combustion are converted into useful energy and thus a higher efficiency than 100 per cent. is obtained. In such cases we have to add an unknown energy X to our formulas. This factor X may represent the energy of the electric vibrations during the combustion.

During the tests which have been carried out with the submerged flame evaporations have been obtained which surpassed the theoretical ones. Samples of the oil which was used during the tests were chemically analysed and burnt in the calorimeter and the exact calorific value of the oil was determined, but for weeks and weeks a higher calorific value and consequently a higher efficiency than 100 per cent. was obtained.

The annexed figure shows a typical Brunler submerged flame boiler. In this case two or three steam generators are attached to one steam reservoir. A burner is placed vertically in the centre of each generator, and the flame is directed downwards. The ignition of the flame is effected through the inclined passage on the left of the burner. The burner is rectangular in cross section, and a water passage passes through its centre.



BRUNLER SUBMERGED-FLAME BOILER

* From a paper by Oscar Brunler, read before the Institution of Chemical Engineers and Chemical Engineering Group (Society of Chemical Industry) on Wednesday, February 11th.

Post Office Engineering Work.

THE public demand for telephone service has continued to increase, and whereas the number of new telephone stations required during 1923 was 200,000, the corresponding number for 1924 was 215,000. In London the net increase in telephones was 40,000. Throughout Great Britain 18 new exchanges were opened and extensions were made to 21 existing exchanges. Amongst the former were the new automatic exchanges at Dundee, Broughty Ferry, Swansea and York, and amongst the latter additions to the automatic exchanges at Accrington, Blackburn and Newport (Mon.). In addition, work was begun on 27 new automatic and on 15 new manual exchanges. Private automatic branch exchanges were completed for 34 firms, and in rural districts 275 exchanges were installed.

During the year three new exchanges were opened in the London telephone area—viz., Franklin, Speedwell and Upper Warlingham, but Franklin is a temporary exchange opened in the Victoria Exchange-building to provide urgently needed relief to the latter exchange. The number of telephones working in the London area at the end of last year was 398,312, and it is estimated that there will be 438,064 working by the end of the present year. The number of calls originated in the London telephone area amounted to about 1,551,300 per day—as an average daily figure for the whole year—which represents an increase of 12.2 per cent. as compared with 1923. As regards the use of the trunk service, the number of controlled trunk calls dealt with in the London trunk and toll exchanges amounted to about 24,696 per day, which is an increase of 13.3 per cent. as compared with the preceding year. The number of trunk lines operated at the trunk toll and central exchanges is now approximately 1482.

In the near future another large exchange will be opened in the City. It will be situated in Wood-street between Gresham-street and London-wall. Owing to the narrow streets in that area the ordinary method of laying conduits for the subscribers' cables by excavation from the surface could not be followed, and it was found necessary to make provision for the construction of a tunnel under Wood-street and London-wall, measuring approximately 700 yards in length. This tunnel will be built up of cast iron sections and will be similar, though on a small scale, to that employed for the London tube railways. It is expected that this tunnel when completed will provide accommodation not only for all the cables required for the new exchange, but also serve as a main artery through the City for cables between distant exchanges in the East and West.

In 1922 the Post Office purchased from the Pneumatic Despatch Company, Limited, a tunnel which connects St. Martin's-le-Grand with Euston Station and the North-West District office in Eversholt-street, Euston. The tube, which is 4ft. 6in. high, was originally constructed for the conveyance of mails between the old Post Office building and the places mentioned. It was authorised in 1864, but was not a success, as it was found impossible to maintain the necessary air pressure. From that time until it was purchased by the Post Office it lay derelict. Although it had been cut away in a number of places during excavations for tube railways and subways, the undamaged portions are in good condition. The tube has now been repaired, and considerable use is being made of it for telephone cabling purposes.

During the year 650 miles of roadway were excavated, and ducts, aggregating no less than 1800 miles, were laid. Moreover, 1000 miles of main cable were laid. These cables contain 106,650 miles of pairs of conductors for trunk and toll use. This is a considerable increase on last year's output.

Telephone repeater stations were opened at Taplow and Marlborough in connection with the London–Bristol telephone cable. These stations, which have an initial capacity of 500 repeaters and are provided with power plant with an output capacity of 40 kilowatts, will operate in conjunction with stations at Gloucester and Newport to provide an underground service to South Wales. The buildings for the Gloucester and Newport Stations are now approaching completion. The initial capacity of each of the latter stations is 300 repeaters. The power plant has an output of 40 kilowatts. Two additional stations are proposed at Taunton and Tavistock to serve the West of England, and it is expected that work on them will be started immediately. On the route from London to Glasgow new repeater stations at Fenny Stratford and Derby—replacing temporary stations—are nearly completed, and will be opened shortly. The initial capacity of the buildings is 700 repeaters. The output of the power plant is 43 kilowatts in the case of Fenny Stratford and 69 kilowatts in the case of Derby. Provision is made in the latter case to furnish power to the telephone exchange in case of emergency. In order to link up the West of England and South Wales with Lancashire and the North East of England and Scotland, a repeater station is being provided in an existing building at Birmingham. Repeater stations are being provided at Canterbury, Marks Tey and Halesworth to serve the South-East and Eastern counties and for continental services, and work on these stations will be commenced in the near future.

TELEGRAPHS.

The economical use of the Baudot multiplex system has now reached its limit, and the programme has been practically completed by the opening of a few "three-station" circuits during the past year. Further developments will be made by extending the use of automatic apparatus on those circuits where the traffic requirements justify it, and by the increased use of re transmitters on omnibus circuits.

There was a considerable increase in the number of circuits worked by the Morkrum teletype. The application of thermionic valves to telegraph wire systems has opened up possibilities in the direction of increasing the number of working channels in each circuit by utilising for multiple signalling purposes trains of waves of different frequencies within the tonic range. The Post Office is at present engaged in trying some of these methods. The tone frequency arrangement should be particularly useful where telegraph and telephone circuits are accommodated in the same cable, and attention is being directed to this phase of the question.

The American "composited" method of superposing telegraphs on telephone trunks has been tried experimentally between London and Penzance. Several trunk lines have been linked together telegraphically so as to form the equivalent of a Morse duplex circuit between the towns mentioned, and the results so far obtained are satisfactory. A second similar circuit was brought into use between London and Chester.

Three one-wire telegraph cables were laid in the West Indies during the first half of the year 1924, between:—(1) Turks Is. and Barbados, length 910 nautical miles; (2) Barbados and Trinidad, length 200½ nautical miles; and (3) Barbados and Georgetown (British Guiana), length 420 nautical miles. The cables were laid by Messrs. Siemens Brothers and Company's cable ship Faraday under the supervision of the Post Office, and will be maintained by the Pacific Cable Board.

A second telephone cable was laid between Aldeburgh (England) and Domburg (Holland). The cables consist of 4 quads capable of providing 8 physical and 4 phantom circuits. The wires are continuously loaded and paper insulated, and are contained in a double lead sheath protected with the usual armouring wires.

A submarine cable of 1.544 nautical miles in length and containing 54 pairs of 70 lb. conductors, paper core, multiple twin, and double armoured, weighing 38 tons per nautical mile and being 3.3in. in diameter, was laid across the Humber between Hessle and Barton.

RESEARCH.

Research work in connection with long-distance telephony was during 1924 connected chiefly with the development of systems employing loaded underground cables in conjunction with telephonic repeaters; but a large amount of work was done in an endeavour to construct underground loaded circuits having a uniform distribution of electrical constants.

Several pieces of apparatus have been designed to enable transmission testing to be carried out with greater speed and accuracy. By the use of one of these it is possible to measure the transmission loss in local junctions and exchange cord circuits and wiring to within a small fraction of a mile of standard cable. Another enables the transmission efficiency of the speaking at a subscriber's office to be measured at the exchange. The use of these sets should enable a much better check to be obtained of the maintenance of the telephone system generally.

Work on the design of Heterodyne oscillators was carried on, and it is expected the complete apparatus will be shortly available, and investigations on substitutes for platinum are still proceeding.

An investigation was carried out on the liability of copper-cadmium line wire to corrode when used with copper or bronze jointing sleeves, and tests are at present in progress to determine the extent to which the corrosion of lead in certain electrolytes is accelerated by alternating currents.

The Orient Liner Oronsay.

No. I.

THE twin-screw Orient liner Oronsay, which left Tilbury on Saturday morning, February 7th, on her maiden voyage to Australia, is a notable addition to the famous fleet of mail steamers owned by the Orient Steam Navigation Company, and managed by Anderson, Green and Co., Limited, of 5, Fenchurch-avenue, London. The post-war building programme of the Orient Line provided for the construction of three 20,000-ton geared turbine twin-screw liners, which, as regards the safety equipment, the comfort and charm of their public rooms, and the up-to-date cabin accommodation, should bear favourable comparison with any other large liners afloat. The first of these three ships, the Orama, was built by Vickers Limited, and the third, the Otranta, is now under construction at the Barrow Yard of the same firm. The Oronsay is the second ship of the programme, and a description of her launch was given in THE ENGINEER of August 22nd last. She was built by John Brown and Co., Limited, of Clydebank and Sheffield, which firm has already constructed at its Clydebank yard four large liners for the Orient Company. The first of these ships, the Orsova, was completed in 1909, and it is still one of the most popular vessels engaged in the Australian trade. As a measure of the progress which has been made in the intervening sixteen years, the Orsova's gross tonnage of 12,000 and her maximum speed of 18 knots may be compared with similar figures for the Oronsay, which, together with some hull dimensions and machinery particulars, are given below :—

Hull Particulars.

Length overall	657ft. 6in.
Length between perpendiculars	630ft.
Breadth moulded	75ft.
Depth moulded to upper deck	47ft.
Load draught	29ft. 9in.
Gross tonnage	20,000 tons
Maximum designed speed	20 knots
Service speed	18 knots

General Cargo Accommodation.

In permanent spaces	103,500 tons
In portable spaces	121,000 tons
Insulated cargo space	152,000 tons

Designed Passenger Accommodation.

First-class passengers	596
Third-class passengers	1268
Officers and crew	2296

Main Propelling Machinery.

Type—Twin-screw single reduction geared turbines, Brown-Curtis type

Total power ahead	20,000 S.H.P.
Total power astern	75 per cent. of ahead power
Speed of turbines	1520 r.p.m.
Speed of propellers	90 r.p.m.
Working steam pressure	215 deg. Fah.

On page 190 we reproduce a photograph of the Oronsay during her official trials, which were carried out on the Clyde between January 11th and 17th. Steam tests were not made on the day on which this view was taken, but on that day, which, as our illustration shows, proved very stormy, only demonstration trials were run. The dark clouds and the background of the Clyde hills combine to make an artistic, if somewhat sombre picture of this fine ship.

Progressive speed trials were run on the Skelmorlie measured mile, and the highest of the mean pair of runs averaged 20.17 knots. On the fuel consumption tests, which were carried out in the Firth of Clyde and on the voyage round to Tilbury, it was ascertained by careful measurement that the vessel could steam at a speed of 14 knots on a fuel consumption not exceeding 60 tons of oil fuel per twenty-four hours, and the corresponding consumption at 18.8 knots worked out at slightly below 150 tons per day. These results must be exceedingly gratifying, both to the owners and the builders of the ship, confirming as they do their calculations as to the advantages to be obtained from relatively fine lines and highly efficient turbine propelling machinery. To these advantages must be added the very material gain in economy secured by driving practically the whole of the ship's auxiliary machinery electrically.

THE SHIP AND ITS DESIGN.

In Fig. 1 we give a longitudinal section of the Oronsay, which, together with the illustration on page 190, will convey to the reader some idea of the general lines of the ship and the distribution of her passenger, cargo and machinery spaces. She has a straight stem with a cruiser stern, two pole masts, and two well-placed raked funnels. The funnels are painted a light buff colour, and the hull is black, with red at the water-line, while the topsides and houses above the line of the bulwark or the upper deck are white. It may be noted in passing that the vessel has in all eight decks—A to H respectively—seven of which are given over to the use of passengers. The Oronsay was built to Lloyd's highest classification, and to the requirements of the Board of Trade and to the Commonwealth Government of Australia regulations regarding first-class passenger-carrying ships.

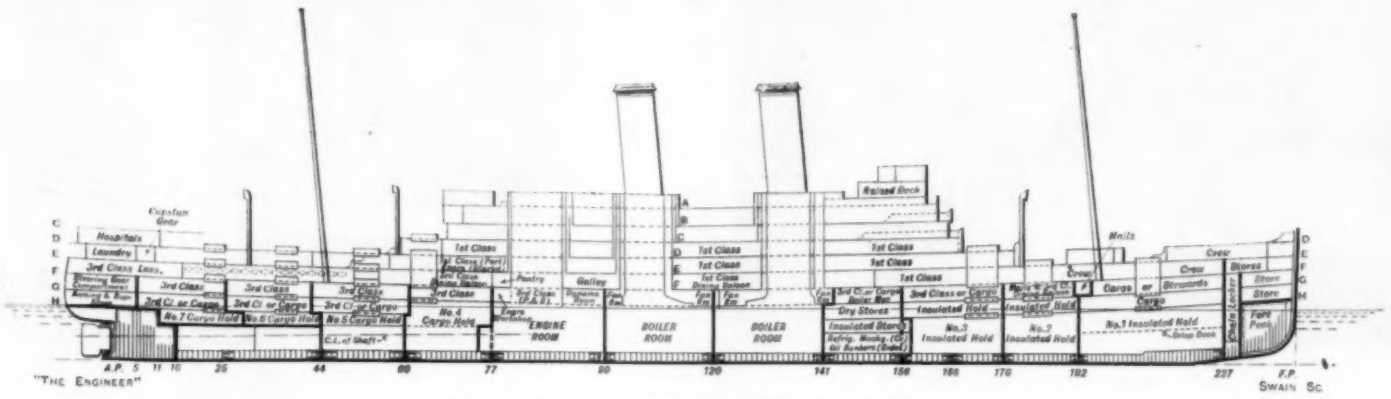


FIG. 1—ORIENT LINER ORONSAY—LONGITUDINAL SECTION

Water-tight Subdivision and the Cargo Holds.—In designing the hull, special consideration was given to its water-tight subdivision, which complies more than fully with the rules of the International Convention for Safety of Life at Sea. The main bulkheads are indicated in Fig. 1, but in addition to them, further protection is conferred by side bunkers, whilst wing tanks at the sides of the machinery spaces and in the compartments immediately forward and aft of those spaces give special protection to a total length of 260ft. As far as possible, it has been sought to reduce the number of water-tight doors to a minimum, and where they are fitted in bulkheads below 'tween decks, they are of the Brunton type designed to be operated either by hand or by hydraulic power. The double bottom extends all fore and aft, and is utilised for carrying fuel oil, fresh water and water ballast. Forward of the boiler-rooms a duct keel has been fitted. It passes through the refrigerating machinery compartment, and the two insulated spaces immediately forward. The duct forms a convenient space for pipes, and enables the piping and the joints to be periodically inspected.

THE PASSENGER ACCOMMODATION.

The Oronsay carries first and third-class passengers only, an arrangement which is becoming more popular in modern liners and one which permits a greater area to be allotted to the public rooms and promenade decks. A feature of the first-class accommodation is the large number—185 in all—of single-berth rooms. There are twenty-two three-berth rooms and the remainder are two-berth cabins. On D deck there are fourteen two-berth cabins *de-luxe*, each with its separate bath-room, while on this deck and the deck immediately above it a large number of the one and two-berth cabins are fitted with cot beds. Several of the state-rooms have intercommunicating doors for the convenience of family parties. We may remark upon the large and airy rooms, and the fact that every first-class cabin has an opening to the outside of the ship, giving direct lighting and ventilation, which is so desirable for vessels sailing the tropics. The cabin furniture and lavatory fittings are exceedingly good throughout. In the centre of the ship almost the whole of the space has been given up to bath-rooms and lavatory accommodation. The sanitary fittings are of the latest type, several having been designed specially for this ship, with a view to simplifying the repairing and cleaning of any section while the vessel is at sea. In all these rooms, both natural and mechanical ventilation is provided.

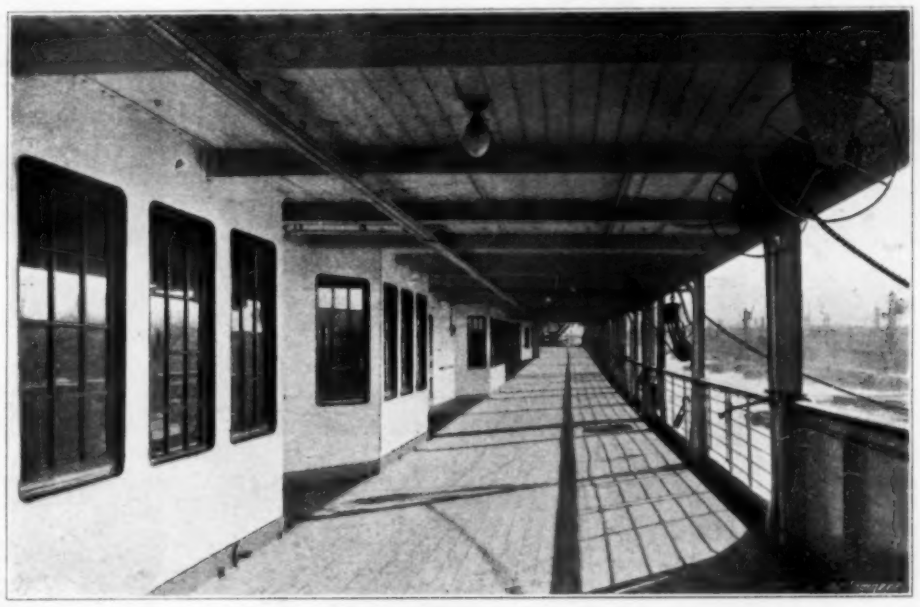


FIG. 2—FIRST-CLASS PROMENADE DECK

Entering the ship from F deck, where one of the embarkation entrances is placed, we find ourselves in the foyer or hall, which adjoins the first-class dining saloon and can, if desired, be used as part of it. These compartments run the full width of the ship, and are lighted and ventilated by hinged side lights arranged in groups of twos and threes. Additional ventilation is provided by means of ceiling fans and punkah louvre fittings. Small tables on the public restaurant system are used, and the room, which has a most pleasing character, is decorated in the style of Louis XVI. period. The walls are panelled and painted in pleasing ivory tones, with appropriate mouldings and decorative features. The furniture and electric light fittings are of a harmonious character, as will be noted from the illustration, Fig. 3, on page 186. A children's dining room and nursery is arranged on the starboard side of E deck.

From the entrance hall a main staircase extends up to B deck, where it gives access to the lounge. A passenger lift by Smith, Major and Stevens, Limited, London and Northampton, is also fitted to inter-

THE TWIN-SCREW GEARED-TURBINE ORIENT LINER ORONSAY

JOHN BROWN AND CO., LIMITED, CLYDEBANK, BUILDERS AND ENGINEERS

FIG. 3—FIRST-CLASS DINING SALOON

FIG. 4—FIRST-CLASS LOUNGE

FIG. 5—ANNEXE TO MAIN LOUNGE

FIG. 6—VERANDAH CAFE ON PROMENADE DECK

FIG. 7—FIRST-CLASS SMOKING ROOM

FIG. 8—FIRST-CLASS DRAWING ROOM

connect the various decks. The first-class lounge at the forward end of B deck is a remarkably fine room. It has a length of about 100ft., and is lighted by no less than forty-one windows, which are arranged forward and at either side in bays. The side doors at the after end each open into an annexe—Fig. 5. The lounge is panelled in veneered mahogany from floor to ceiling, and this scheme of decoration is enhanced by columns of Schemtau Breche marble with bases and capitals in bronze. The floor is laid with oak parquet work, and the rugs of Persian design lend a pleasing decorative effect. The general character of the settees, small tables and chairs, executed in Louis XVI. style, will be noted from the illustration we reproduce in Fig. 4. A large skylight is provided over the stairway, and a decorative panel fitted over the stairway entrance is a pleasing feature.

At the after end of the bridge house on E deck there is a second large stairway for the use of first-class passengers. It ascends to the first-class café—see Fig. 6—which gives easy access to the main smoking-room. This room—which we illustrate by

FIG. 9—LIFEBOATS SUSPENDED FROM THE DAVITS

Fig. 7—is charmingly decorated. It has two large bay windows and smaller windows, in addition to a domed ceiling lighted by three artistically designed fanlights at either side. The walls are panelled in Italian walnut, and the effect is enhanced by Dutch paintings and furnishings with richly coloured lacquer work. A number of writing tables are arranged in convenient places. The verandah café affords a comfortable and airy lounge, which will be appreciated in warm climates. Another fine public room is the drawing-room on C deck, illustrated by Fig. 8.

Special reference must be made to the extensive promenade deck space, designed for the enjoyment of first-class passengers—see Fig. 2. Excellent accommodation for games is provided, while on all decks sheltered recesses have been made for deck chairs and also provision for dancing by screening off part of the deck adjacent to the verandah café.

We need hardly refer to the hospital, dispensary, offices, shops and so on, which should add to the convenience and pleasure of the passengers.

The third-class passengers are accommodated on G and H decks, and a very large proportion of the rooms is arranged for two and four persons, while a considerable part of the accommodation has been fitted in a portable manner in order that the space may be utilised for the conveyance of cargo on the voyage home. The rooms are large, well lighted and ventilated, and are, we consider, in considerable advance of the type of third-class accommodation which is usually provided on boats of this class.

The main public rooms for the third-class passengers are all situated on F deck, and they comprise a large dining saloon, lounge and a smoking-room. The walls of the dining saloon are framed and panelled in oak, and the space is well lighted and ventilated by means of large side windows and punkah louvres. Entrance to the public rooms is obtained by means of the stairways from below or from the covered promenade. This covered promenade is open at the ship's sides, and forms a comfortable place where passengers may obtain an airing while being sheltered from the sun at sea. The lounge is finished with large panels painted white, whilst the furniture is of polished mahogany, and includes settees, small tables and chairs. The smoking-room is furnished with small tables and chairs, and is of a superior type for this class. The walls are panelled in oak in Jacobean style, while settees and easy chairs have been chosen with a view to comfort. A smoking-room of a generally similar type is to be found on E deck forward.

In addition to the covered promenade we have mentioned, extensive promenading space for third-class passengers is provided on D and E decks forward and also aft, as shown in Fig. 10.

The captain and navigation and wireless officers are accommodated in excellent quarters, arranged immediately beneath the navigation bridge, whilst the engineers' cabins are situated on the starboard side of E deck, slightly aft of the main engine casing. Other members of the executive have been allotted appropriate cabins, arranged in accordance with their respective ranks. With regard to the crew, the seamen are berthed underneath the forecastle deck, and the boiler attendants and greasers' rooms are on the starboard side of G deck, just forward of the boiler hatch. Special attention has been paid to the comfort of the crew, in the important matter of baths, showers, and sanitary accommodation, and the facilities provided are well in excess of the regulations laid down by the Commonwealth Government.

SAFETY EQUIPMENT.

Earlier in this article we have made reference to the careful division of the ship by water-tight bulkheads and the side protection afforded by the wing tanks and oil bunkers. A special feature of the boat equipment is the provision of fourteen sets of Maclachlan type gravity davits, twelve of which each operate two large nested lifeboats, while the remaining two sets each serve a 30ft. motor lifeboat. The davits were supplied by the Maclachlan Automatic Boat Davit Company, Limited, of Glasgow. The trackways over which the boat cradles move are secured to the deck and form a part of the ship's structure. The two boats are suspended from the cradle by single wire-rope falls, attached to a hand winch, which lowers the boat on an even keel. On releasing a safety catch and lifting the winch brake the cradle with the lifeboats moves under gravity down the trackways and over the ship's side, the cradles themselves coming to rest on stopper pins. When the passengers have embarked the boats may be lowered into the water by the brake. Fig. 9 shows two boats in the lowered position. It will be seen that both are transported over the side of the ship together, the outer boat of larger capacity being launched first, while the inner boat remains suspended below the davit heads by two wire rope pennants. This arrangement has the advantage that almost two-thirds of the ship's complement can be accommodated in the first boats to get away. When these have been launched the empty falls can be easily and rapidly recovered by a quick return electric hoisting gear fitted to the boat winches. We may comment upon the neat way in which the boats are stowed. The davits are so arranged that about 6ft. of headroom is given beneath the boats, while in the fore and aft direction there are only about 14in. between the stem of one boat and the stern of that adjacent to it.

A welcome feature of this arrangement is the free ship's rail, which greatly increases the available deck space. Indeed, we may say that we have rarely seen a finer boat deck on any recent large liner. On the after deck there are other lifeboats and collapsible boats suspended from davits of the Welin type. Lifeboat accommodation is thus provided for 2304 persons, and, in addition, a full complement of life belts is carried, whilst lifebuoys with the necessary lights and lines are placed at intervals on all the weather decks.

The preventive measures against fire include the usual fireproof bulkheads and extinguishing apparatus, and in all the boiler compartments Foamite–Firefoam plants are installed.

Emergency Lighting Set.—On the boat deck aft an emergency lighting set is installed. It is of sufficient capacity to maintain the necessary lighting, wireless, and power services of the ship, even in the case when the main auxiliaries on G deck level are placed out of operation by flooding. This set, which is self contained, includes a 36-kilowatt dynamo driven by an Allen hot built engine.

Telephone and Wireless Services.—The equipment necessary for the internal control and navigation of the vessel includes an installation of Graham's loud-speaking telephones, which provide communication between the navigating bridge and the engine-room, the docking bridge, the forecastle head and the steering gear compartment. For the executive work of the ship a separate telephone system with its own exchange is fitted. The wireless equipment is of the latest type, and fulfils all the modern requirements for navigation and passengers' use. We need hardly mention the excellent service of cabin bells, electric clocks, fire alarms, &c.

For the amusement of the passengers a cinema outfit is carried, the machine being placed in a special compartment adjacent to the emergency lighting set room on the boat deck.

AUXILIARY MACHINERY AND MECHANICAL APPLIANCES.

All the deck machinery with the exception of the anchor windlass and two capstans, is electrically driven, and two systems of transmission are employed. Some of the cargo winches and the boat-hoisting winches are directly coupled to their driving motors, but for the remaining machinery the Hele-Shaw and Williams-Janney electric-hydraulic systems, in which a constant speed motor drives a variable delivery oil pump, are employed. In the case of the steering gear the oil delivered by the pump is used to actuate a set of hydraulic rams coupled to the tiller arms, while for the winches and the aft capstans it serves to work an hydraulic engine whose speed and direction of rotation varies directly with the quantity and direction of flow of the oil delivered by the pump.

Steering Gear.—This gear is placed in a special compartment right aft on G deck. It is of the Hele-Shaw Martineau type, supplied by John Heatie and Co., Limited, of Greenock. The electric hydraulic gear is in duplicate, and each set is designed to be capable of running the rudder from hard over to hard over in thirty seconds. The four cast iron hydraulic cylinders are firmly bolted to the deck framing, and the motor and pump units are arranged above the outer ends of the cylinders, with the necessary control and change over valves. The two pairs of opposed rams are coupled to the double-ended steel tiller, so that each pair work in opposite directions and produce an equal turning movement on the rudder stock.

The steering gear is controlled from the navigating bridge by means of a telemotor drive, and it may also be operated by hand from the steering compartment and by shafting and gearing from the docking bridge aft.

Winches, Capstans and Windlass.—The cargo winches are thirteen in number, and comprise ten Hele-Shaw electric-hydraulic winches, by MacTaggart, Scott and Co., Limited, Loanhead, Edinburgh, and three by Napier Brothers, Limited, Glasgow. Great care has been taken in the grouping of the winches and derricks, so that rapid cargo handling is obtained. The winches serve seven cargo hatches, and nineteen derricks capable of a 5-ton lift are fitted, with one forward for heavy lifts up to 20 tons. On E deck at the after end there are placed on either side of the

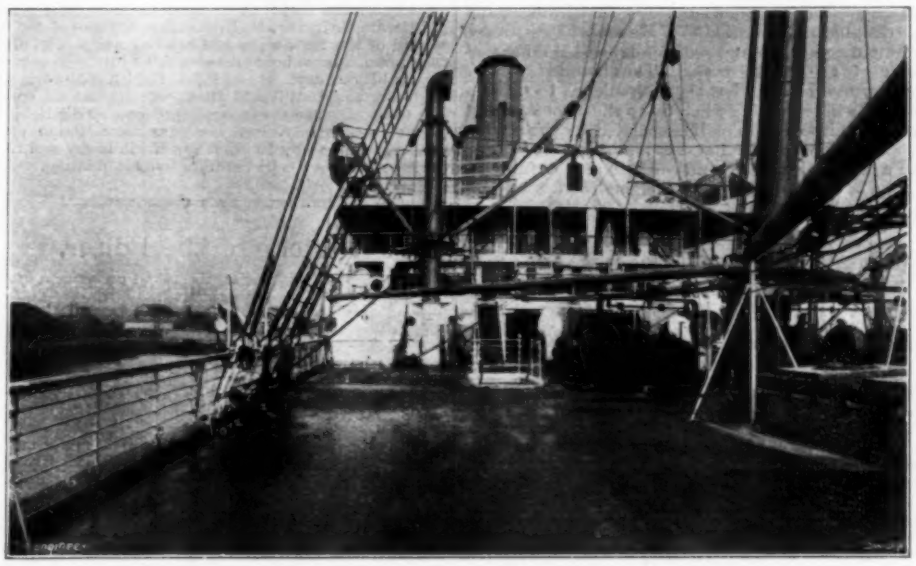


FIG. 10—THIRD-CLASS PROMENADE DECK

laundry house two electric hydraulic capstans, by Napier Brothers. They work on the Williams-Janney principle, and the motors and pump gear are placed inside a deck house. These capstans are designed to exert a pull of 16 tons at a speed of 35ft. per minute, and are geared to haul in slack rope at a speed of not less than 150ft. per minute. Two steam-driven capstans are placed port and starboard on the forecastle, and are worked independently by shafting from engines placed on E deck immediately below the capstans. The steam windlass with warping ends was, like the four capstans, supplied by Napier Brothers, and it works the stockless anchors, two of which are stowed in the hawse pipes.

Heating and Ventilation.—The heating and ventilation of the ship was very carefully considered, and has been carried out by the builders. Steam heating is provided and connections are made for the use of electric radiators in the cabins. As regards ventilation, over twenty supply and exhaust fans, all electrically driven, were supplied by Davidson and Co., Limited, Belfast, while another 50 were installed by the Thermotank Company, of Glasgow, in connection with its patented punkah louvre and inductor systems. In the punkah louvre system air under pressure is delivered to ducts having a series of outlets, each fitted with a ball jointed mouth-piece, giving universal directional control. By this means the air supply can be directed on to the floor or to any part of the room to meet the wishes of the occupants of the cabins or public rooms.

Kitchen and Galley Equipment.—The kitchens of the Oronsay are arranged between the first and third-class dining rooms on F deck. They are unusually complete and include the latest food preparing and cooking appliances, special rooms being set apart for bakery, confectionery, butcher, dairy, cold larder and still rooms. We need but briefly refer to the many ingenious minor cooking devices, such as automatic toasters, egg boilers, grills, &c. The main range is oil fired and was supplied by John Phillips and Co., Limited, of Glasgow, which firm also supplied the other baking machinery. Means are provided whereby the burners of the range can be regulated to give fine temperature control with ease of operation on the part of the attendant. The dough-mixing machinery and other appliances were built by the Morton Machine Company, Wishaw. The pantries and sculleries are situated close to the dining saloons, and are fitted out with the latest steam and electrically-heated services. We may mention that a large range of insulated ship's store-rooms on H deck forward of the boiler rooms is set apart for the reception of perishable stores.

The Laundry.—In roomy quarters aft on E deck a fully-equipped steam laundry has been installed. The machinery, which in all cases is electrically operated, was supplied by I. Braithwaite and Son (Engineers), Limited, of Kendal. It includes washing machines, hydro extractors, and ironing machines of the latest types. The laundry service should prove of considerable convenience to passengers, and will certainly be helpful to the owners in that it will permit the store of linen carried by the ship in any one voyage to be reduced to a minimum.

In a second article we purpose to give a full description of the propelling and engine-room auxiliary machinery.

SIXTY YEARS AGO.

THE year 1769 saw the birth of Napoleon, Wellington, Humboldt, Mehemet Ali, Lord Castlereagh, Brunel and Cuvier. It witnessed also Arkwright's first patent, the first patent of Watt, and, according to a note in our issue of February 10th, 1865, the construction of the first steam carriage, that of the Frenchman, Cugnot. This steam carriage was then—1865—still in existence in the Conservatoire des Art et Métiers at Paris. We described it as possessing a copper boiler very like a common kettle, without the handle and spout. This boiler furnished steam to a pair of 13in. single-acting cylinders, which were connected to a single driving wheel that was roughened on its periphery. The engine, we considered, bore remarkable testimony to the mechanical genius of its inventor, and no true Englishman it was held would begrudge the French claim to priority in the efforts to evolve a system of land propulsion which was based upon Cugnot's steam carriage. The machine was not, however, successful. It overturned once or twice on the bad roads then existing in France and was put aside. Arrangements, it would seem, were made to demonstrate it before Napoleon in 1801, but his departure for the campaign in Egypt prevented the trial being conducted. It may thus be said that Napoleon missed the opportunity of rendering himself famous as the earliest patron of the steam locomotive, just as he missed at a slightly later date a similar opportunity presented by Fulton of becoming an active supporter of the earliest attempts at marine steam propulsion. . . . In the same issue an article appeared entitled "The 'Fatigue' of Metals." This is the earliest instance, we believe, of the use of the word fatigue in this journal, although we cannot claim to be the first to have applied it in its now familiar connection. That honour seems to be due to Mr. Frederick Braithwaite, who shortly before our article appeared had read a paper bearing the same title before the Institution of Civil Engineers. It would appear that in the then recently published results of Fairbairn's experiments on the resistance of iron to repeated loading engineers recognised the true explanation of many mysterious failures of structural and machine members under loads which statically applied should not have broken them. It was just becoming generally accepted that it was the repetition of the load that caused the failure. But as to why the repetition should have this effect few, it seems, could agree. Our own view advanced in the article referred to was that if the load exceeded the elastic limit by only a slight amount the metal would become increasingly brittle until in the end its ductility was entirely taken out of it and it would fracture without extension. This theory, elaborated by quotations from the results of a variety of long-forgotten experiments, seems to-day ingenuously simple. But it must be remembered that it required much additional tedious and prolonged experimentation before it was definitely established that the point now known as the fatigue limit may be well below the elastic limit.

MANCHESTER ASSOCIATION OF ENGINEERS

THE annual dinner of this Manchester society was held at the Midland Hotel on Tuesday last, under the chairmanship of Mr. Herbert Bates, M.I. Mech. E., president. The attendance was quite up to the average of former functions of this kind, and a very pleasant evening was spent, in spite of a tendency on the part of several of the speakers to dwell rather unnecessarily on the prevailing depression in the engineering industry. The Lord Mayor of Manchester, Mr. F. J. West, M.I. Mech. E., an ex-president of the Association and chief guest of the evening, made the type of speech which is appropriate to the occasion in reply to the toast of his health, proposed in eulogistic terms by Mr. C. Bentham, M.I. Mech. E., who held the present Lord Mayor up as a shining example of an engineer who, in addition to his business activities, also found time to take an unusually keen interest in public affairs. In reply to the toast of "The Manchester Association of Engineers," the president, in referring to the depression in trade, said that one of the most serious obstacles to the return of normal trade conditions was taxation, and he thought it unfair that the present generation should be called upon to bear the full burden of the late war instead of leaving part of the burden to posterity. Heavy taxation, he said, had the effect of restricting the efforts of the industries, and suggested that a better course was to find a means to reduce freights, imperial and local taxation and the cost of living, and thus enable manufacturers to fix lower prices to attract trade. He instanced the deplorable fact that British shipbuilders were now quoting two prices for vessels, one in which British steel plates were to be used and another in which continental materials were to be employed. If that practice were extended and makers of machinery decided to purchase pig iron, steel ingots, bars, forgings and castings from abroad, the outlook for some of our great industries would be sad. If the supply of these materials from British works stopped, prices would rise, since the mines, collieries and coke oven plants would depreciate owing to idleness to a point from which recovery would be difficult. The toast of "Our Guests" was proposed by Mr. H. Pilling, M.I. Mech. E., who alluded to the increasing competition which British engineering had to face from France. He said that since the Paris Exhibition in 1900 French engineering had made tremendous strides. This toast was replied to appropriately by the Mayor of Salford, Mr. G. Billington, and Mr. Gerald G. Lynde, M. Inst. C.E., chairman of the local section of the Institution of Civil Engineers. Mr. Lynde took a much more hopeful view of the future of engineering in this country. He said that British engineering and engineers could still hold their own against all comers. The toast of "The Chairman," proposed by Sir Benjamin Longbottom briefly, but with due appreciation of the services rendered by Mr. Bates to the industry and to the Society, brought the proceedings to a termination.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

TELEPHONES.

SIR,—Will you allow me to congratulate you on the article on telephones published in your issue of the 6th inst., and at the same time to deal with one or two points that seem to arise therefrom?

First, with regard to the effect of our deputation to the Postmaster-General at the end of last year. The official report was sent to you at the time, and I enclose a short note on the same subject herewith, from which you will see that the attitude of the Postmaster-General towards telephone development on a big scale in this country is entirely sympathetic. You will, no doubt, have observed that in reply to a recent deputation from the printing trade, urging restoration of penny postage, the Postmaster-General emphasised the point that the Post Office was committed to considerable capital expenditure to provide for expansion of the telephone service.

With regard to the question of cost, it is almost impossible to compile tables showing comparative costs in other more densely telephoned countries, for the reason that the conditions vary in each case, making it impossible to arrive at a standard unit of comparison. At the same time, it is the case that the present tariff in this country, which has been reduced five times since 1921, compares favourably with the tariffs existing in other countries where telephone density and usage are considerably higher. I do not think there are many cases in which people have contemplated installing a telephone but have been deterred by the cost, specially now that the installation charge has been done away with. The under-development is, I suggest, much more due to the lack of knowledge of what the actual cost really is. How many people, for example, out of the 46,000,000 in this country who are not telephone subscribers, realise that the rental works out at half a crown a week in London, less in the provinces, that all incoming calls are free, and that local calls cost a penny? Even the people who have telephones are, to a great extent, unaware of the many subsidiary services of which they can avail themselves, or, if they do know, make no use of them.

You rightly emphasise the importance of telephone development in this country from the point of view of its effect on unemployment in a great many trades, and it might be worth while to point out that the expenditure of additional capital on this service is not only remunerative to the taxpayer, but also to the State, the telephone service being a revenue-earning one, and making at present a profit of 7½ per cent. on the capital therein invested.

H. E. POWELL-JONES, Secretary.
The Telephone Development Association,
Aldine House, 10-13, Bedford-street, W.C. 2,
February 9th.

SIR,—With reference to your leading article on telephones, and to the relatively scanty use which this country makes of them, there is one aspect of the question which I have not seen mentioned. Admitting that more energetic canvassing might result in an increased demand, is it clear that the comparatively tardy recognition of the telephone may not be due to racial characteristics? Is it known, for example, that the Briton's power of reception through the ears is equal to that of other nations, or, alternatively, that his receptive powers usually are not superior?

This is hardly an engineering problem, but the vast differences between the methods of persons of apparently equal mental calibre, in assimilating knowledge is remarkable, and, of course, it is well known that an accident to the sight may be compensated by increased aural receptivity, and *vice versâ*.

This point is not without importance, in view of the enormous popularity of the cinema and even the increase in the numbers of the public who regularly visit football matches, and other athletic contests, where sight and not sound is the dominating faculty in operation. I have liked to conjecture whether in the future this tendency may not affect the hearing of the civilised races, but just as this speculation was becoming interesting the advent of wireless will probably restore the equilibrium between the two senses.

A. H. HALL.

Blackheath, S.E. 3, February 9th.

THE CLOSURE OF FINSBURY TECHNICAL COLLEGE.

SIR,—The closure of Finsbury Technical College, for lack of financial support from the City Companies and the London County Council, has been determined upon to take place at the end of the year 1926, and there seems little hope that the London County Council will reconsider its decision.

It will be remembered that, as a result of strong protests three years ago, the London County Council decided to support the institution for a further period, but it seems now to be an established fact that Finsbury Technical College can no longer attract a sufficient number of students desiring to advance their technical knowledge, but having no anxiety to obtain University degrees.

The passing of any institution of this kind raises inevitably the question of the future of the staffs engaged. While any institution threatened with closure remains open, staffs must be maintained, and men who have served long and faithfully the cause of education should not, like their institutions, be regarded as superfluous or redundant. Unfortunately, there is no indication in the attitude of the London County Council that as yet that body has considered the position of the staff, and has made any provision for their subsequent employment. Accordingly, at the annual Council meeting of the National Union of Scientific Workers, held on January 31st, the following resolution was put and carried unanimously:—"In view of the fact that the closure of the Finsbury Technical College is a certainty, the London County Council is urged to make provision for the absorption in other institutions, with seniority, of those members of the staff who will be on the staff when the College closes." Copies of this resolution are being forwarded to the chairman of the London County Council Education Committee.

A. G. CHURCH, General Secretary.
National Union of Scientific Workers,
25, Victoria-street, S.W. 1,
February 6th.

SHIPS' MOTOR LIFEBOAT.

SIR,—My attention has been called to an article under the above heading in your issue of the 6th inst. You state that the boat "was designed and built by the Parsons Motor Company, Limited, in conjunction with the Despatch Boat Company, which constructed the boat." This would give the impression that the Parsons Motor Company was responsible for the design, which, however, would be incorrect.

The whole of the plans, with the exception of those relating purely to the machinery installation, including the preliminary drawing on which the tender was based, were carried out by myself as consulting naval architect to the Despatch Boat Company.

I may add that particular care was taken over the design, and the calculations involved were fully verified on the exceptional speed for such a boat and for the stability, as confirmed by the Board of Trade official inclining tests.

No words of mine are necessary as to the Parsons engines, which are most deservedly well known, nor to the excellent way in which the Despatch Boat Company carried out my ideas.

I think, however, the designer of a boat should receive a certain amount of acknowledgment, since it is usually the poor designer who is blamed if anything goes wrong.

Trusting you will be able to give publicity to my remarks.

A. JOE WHITE.

Gurnard Bay, I.O.W., February 10th.

WASHING OUT LOCOMOTIVE BOILERS.

SIR,—I should be glad to have the experience of others as to the number of miles a railway locomotive may be run with good water before requiring to be washed out. What are the complications, if any, likely to result if they go too long? Is there any danger of corroding and bulging of fire-box and boiler plates? Any other information relative to this subject I should esteem a great favour.

February 10th. INTERESTED.

THE Maroondah Dam, which is being constructed in the valley of the Watt's River, for the supply of water to Melbourne, will have a total available capacity of 4855 million gallons. It is being built of concrete and will be 135ft. high by 946ft. long.

Railway Matters.

THE first of the dividends for the latter half of 1924 to be announced is that of the Metropolitan. That company pays 6 per cent., or 5 per cent. for the whole year. The latter figure compares with 4 per cent. in 1923, 3½ per cent. in 1922, and 2¼ per cent. in 1921. The traffic for the British Empire Exhibition was a great asset last year, but independently of that, good progress is very evident.

THE interesting case of a workman injured in the Gravesend collision of August 21st, 1922, was reversed in the Court of Appeal on the 5th inst. The user of a workman's ticket is limited, in the event of accident, to compensation for £100. It was sought to make this man an exception, inasmuch as his ticket was bought for him by the Ministry of Health, and, as related in this column on December 12th last, he was awarded £800. Against this decision the railway company appealed, with the result stated above.

ALTHOUGH the railway accident returns show that the failures of engine equipment are not more frequent than they used to be, their occurrence to-day receives greater attention than formerly in the Press. Paradoxically, though, that may be due to their very rarity; were they more common, less attention would be attracted by them. Among such failures of late was a broken coupling-rod on the Charlestown curve of the London, Midland and Scottish Railway and a broken crank pin near Abbotts Ripton.

SPEAKING at Torquay recently Sir Felix Pole, general manager of the Great Western, said that electrification was put forward as a cure for everything on the railways. "For the last two years," he added, "I have had a committee at work trying to discover places where the traffic would justify electrification. So far we have not been able to produce a scheme, and the best information I get rather tends to make me believe that to a very large extent the idea of the electrification of railways is not well founded."

SPEAKING at the Institute of Transport on the 2nd inst., Mr. H. A. Watson, the late general superintendent of the North-Eastern Railway, said of the automatic signalling installed in 1904 on the 10-mile stretch between Alore and Thirsk that it had been a very great success indeed. The company's expectations with regard to what it was going to accomplish had been fully realised; it had worked most efficiently, and there had been very few failures with it. He could only hope that the use of such systems would be extended.

IN view of the anticipated increase in the tourist traffic to Ireland, it is hoped that the railway accommodation at Kingstown Pier will be improved. We believe it is the same as when the line was opened in 1836. The *Irish Times* calls for immediate improvement, pointing out that now that the Free State railways have been amalgamated and are working in co-operation with the London, Midland and Scottish Company, there is no further excuse for delay in the removal of one of the most serious obstacles to a profitable tourist traffic.

ON February 3rd Sir Leslie Wilson, the Governor of Bombay, opened the first electric railway in India, when he set in motion the first train on the "Harbour Branch" of the Great Indian Peninsula Railway, which feeds the Bombay docks and that portion of the suburbs of Bombay towards Kurla, a distance of 10 miles. The section which has been electrified constitutes the first step in a general scheme of electrification of the suburban lines as far as Kalyan, 30 miles from Bombay, the whole of which is expected to be completed by the beginning of 1927.

THE Railway Rates Tribunal has set up a time table for the proceedings connected with the settlement of the standard charges. They will begin on Monday, March 2nd, and eight subsequent stages are provided for up to and including July 6th. The final proceedings are intended to begin on October 12th, and it is hoped to name January 1st next as "the appointed day" specified in the Railways Act, 1921. The proposed time table came before the various parties at a meeting of the tribunal on the 4th instant, when both the railway and traders' interests said that it would be impracticable for January 1st, 1926, to be the "appointed day." The President said that they would be bound to give great weight to that opinion.

THE cause of compulsory arbitration, before a strike or lock-out can be effective, has received a setback by the judgment given by the Privy Council on January 20th that the Canadian Lemieux Act—the Industrial Disputes (Investigation) Act of 1907—is *ultra vires*. Under it no employer is allowed to lock-out or a servant to strike until the point in dispute has been considered by a Board of Conciliation. If this course be neglected, an employer is liable to a fine of not less than £20 and not more than £200, and a servant to not less than £2 nor more than £20. From some figures we have by us, it seems that in the six years, 1907–1913, seventy-four railway disputes were taken to the Board, of which sixty-seven were adjusted. In other trades there were seventy-one disputes, of which sixty were disposed of.

THE coroner's jury which inquired into the four deaths arising out of a train being blown over on the 30th ult., when crossing Owencarrow Viaduct on the Burtonport Extension, added a rider to their verdict that if a properly protected rail had been carried along the whole length of the viaduct, without any intervening gap, no lives would have been lost. If no guard rails were used on the bridge, some explanation appears to be necessary, in view of a clause in the Requirements as to New Railways, which insists: "On important viaducts where the superstructure is of iron, steel or timber, substantial outside wheel guards to be fixed." The Burtonport Extension was built by the Government and opened in 1903. It may be added that when a similar accident, but without any fatalities, occurred on the Leven Viaduct, Furness Railway, in 1903, the late Colonel Druitt recommended that substantial parapets should be added. If, however, that would affect the stability of the bridge by the amount of wind pressure brought to bear upon it, some means should be devised for warning the signalmen on either side when the wind was of sufficient force to be likely to cause danger to trains passing over it.

Notes and Memoranda.

ACCORDING to the American Bureau of Mines, pure limestone, dolomite, gypsum and anhydrite are the best materials for stone dusting in coal mines.

THE reinforced concrete chimney at the Yallourn power plant is said to be the tallest structure in Australia. It is 330ft. high by 11ft. 6in. in internal diameter. The external diameter at the base is 16ft. 10in.

AN oil pipe line, which was recently laid in America with acetylene welded joints, was tested after 93 miles had been completed. It included 25,000 separate welds and was tested to 740 lb. per square inch, but only one bad joint and three pinholes were found during the test.

THE question of the rating of storage batteries for wireless service has been under discussion among various American manufacturing companies. The need for standardised ratings for these batteries is recognised throughout the industry, since many batteries now being sold are obviously over-rated. No formal action has, however, been taken in this matter.

A DESCRIPTION is given in the *Engineering News-Record* of a novel method employed in San Francisco for taking the weight of the concrete columns of a seven-storey building while they were underpinned. Collars were built up round the lower part of the columns by means of a cement gun and steel joists were lodged under these collars to carry the weight. The columns were 26in. square and the collars 25in. deep by 8in. thick, reinforced by ¼in. steel wire.

IN a new German process for welding aluminium use is made of a special solvent for dissolving the oxide layer, apart from which the procedure coincides exactly with that for ordinary lead soldering. Using oxy-acetylene, a mixture of 60 parts potassium chloride, 12 parts sodium chloride and 4 parts potassium sulphate, had been found to give favourable results. With a less heating flame it is advisable to use somewhat more potassium sulphate in order to reduce the melting point of the mixture. The flux is applied to the parts in powder form or as a watery paste, and heated in the flame till it melts, whereafter the aluminium itself soon melts.

MANY patterns can, according to Mr. H. A. Whiteley, be stamped in duralumin using the same dies as for steel. Although the coefficient of expansion of aluminium is twice that of steel, the forging temperature is only half, and so dies with a shrinkage allowance for steel should be suitable for duralumin. In practice it is found that duralumin stampings are slightly on the large side compared with steel. Better results are obtained by modifying the steel design to suit duralumin, bearing in mind the fact that duralumin does not flow quite so readily as steel. This will mean that all sharp corners are to be avoided and that, where possible, changes of section are made more gradual.

ONE of the principal sources of coal dust is the operation of the machines used in undercutting the coal. The best way to keep down dust from this source is to use a water spray on the cutter bar. Dust made in cutting the coal should also be loaded out or shoveled out before the coal is blasted down, so that it will not be thrown into the air and carried away, to be deposited elsewhere by the ventilating current. Another source of dust is the siftings from leaky cars or what is blown by the air currents from loaded and emptied cars in transit between the working face and the mine opening. Drenching the cars with a water spray while they are in transit is an effective and economical way to keep down the dust from this source. A third cause of dust is the pulverising of lumps of coal which drop off the loaded cars, fall on the track, and are gradually reduced to dust by the continual passage of the trips.

COMPRESSED air explosions are, according to *Industrial Gases*, usually attributed to oil and oxygen, the peculiarity of such explosions being the enormous energy developed in proportion to the small amount of combustible matter present. If the container is made of steel it sometimes burns up almost like celluloid, or it may splinter into fragments like glass. Investigation into the causes of such explosions shows that temperature is an important factor. The two principal factors are found to be (1) slow leakage of high-pressure gas carrying oil with it through a very small opening—that is, by internal friction generating heat; and (2) by sudden compression of the layer of oxygen nearest the end of a closed passage, due to the impact of high-velocity oxygen released from a suddenly opened valve, or to direct connection with the compressor. Tests have shown that the initial charging pressures of oxygen carried in commercial cylinders, usually about 2000 lb. per square inch, may develop an explosion pressure of 20,000 lb. per square inch when a few drops of mineral lubricating oil are warmed up to explode simultaneously.

WRITING in the *Drop Forger* on the subject of steels for forging machine dies, Mr. E. R. Frost says that, on account of the small sections of heading tools compared to the stresses they must stand, such tools must possess great toughness, and from 60 to 65 scleroscope is about as hard as they should be. Heading tools for forming cone upsets, or those having diameters greater than that of the stock impression being worked upon, are, of course, more rugged, and can be used at hardnesses of from 65 to 75 scleroscope. Punches can run from 60 to 70 scleroscope, depending upon the cross section of the punch in relation to the depth of hole. It has been noted, by the way, that abrasion on punches is materially lessened if the hardening scale is not removed from the surface of the punch. To grind or polish a punch after hardening seems to be one of the sure ways to cause the punch to score. A punch, representing a case in which the relative area of the hot stock is large, requires great heat-resisting properties, and low carbon tungsten steel shows excellent results for such service. In the case of shear tools, cutters or punches for punching thin sections, the tungsten steels possessing the higher percentages of tungsten give the longest life, on account of their better abrasive hardness at elevated temperatures, and these can be used at from 75 to 85 scleroscope.

Miscellanea.

A SCHEME is being prepared for a system of subways in St. Louis, which, it is expected, will involve the expenditure of 100,000,000 dollars.

THE water consumption in Sydney, New South Wales, last year amounted to 58,628,514 gallons a day for a population of 1,254,020, or, say, 47 gallons a head.

THE two most recent monographs compiled by the Imperial Institute, and published by Mr. John Murray, deal extensively with the ores of antimony and bismuth.

THE Cochin Harbour Conservancy Board has decided to borrow Rs. 20,000,000 from the Government of Madras for carrying on the third stage of the harbour development.

THE bridge which is to be built over the White Nile at Khartum by Dorman, Long and Co. is to have nine spans of 240ft. each. One of the spans will be of the opening type.

DURING excavation work for a sewer in Coatbridge a seam of coal 7ft. thick was discovered at a depth of 35ft. From 9 to 10 tons of best house coal are being taken from the hole daily.

THE Government has agreed to make grants equivalent to 75 per cent. of the cost, £4,750,000, of the proposed tunnel under the Mersey between Liverpool, Birkenhead and Wallasey.

THE total quantity of coal raised in the United Kingdom in the fifty-two weeks ended December 27th, 1924, was 269,134,000 tons, against 276,000,000 tons in 1923 and 287,430,000 tons in 1913.

AFTER nearly six years of litigation it has been decided that the failure of the molasses tank, which burst in Boston, United States, on January 15th, 1919, was due to inherent weakness of the tank itself.

THE Sunderland Corporation has decided to build a new bridge across the Wear in place of the Wearmouth Bridge, which is regarded as dangerous. The new bridge is to be 80ft. wide and will cost over £200,000.

IT is proposed to construct a causeway 23.3 miles long across Lake Pontchartrain, near New Orleans. It will include two bascule bridges and 6 miles of concrete trestle. The cost is put at some 12,000,000 dollars.

A COMMITTEE of the American Society of Civil Engineers has recommended that the permissible working stress for structural steel should be increased from the present standard of 16,000 lb. to 20,000 lb. per square inch.

THE new storage reservoir at Lake Metis, Quebec, which has just been completed, will impound 18,000 million gallons of water in a lake over 20 miles in length. The object of the dam is to regulate the flow of the Metis River.

THE new third shaft at the Brodsworth Colliery was worked for the first time last week. At present it extends only to the Barnsley seam, but from the other shafts at the colliery it is hoped shortly to work the Parkgate seam.

FOR the purpose of increasing the water supplies in Madras from 25 gallons a head to 30 gallons a head, it is proposed to raise the level of Red Hills Lake by 18in. The extra height would increase the storage capacity from 2162 million cubic feet to 2440 million cubic feet.

THE great graving dock at Durban has been completed, but it can be pumped out only about midday or in the evening, as, according to the *S.A. Mining and Engineering Journal*, the municipal power-house is unable, at other times, to provide the necessary electrical power.

THE Manchester Waterworks Committee has resolved to begin at once the work of adding Haweswater to Thirlmere for the purposes of water supply. The scheme will cost £10,000,000 and will involve doubling the size of the lake and the construction of a 74-mile aqueduct. The work must be completed in nine years.

AFTER the last car had passed work was started on a recent Saturday night in Glasgow on renewing a tramway junction. The work involved the breaking of 131 rail joints, held together by 786 bolts, the removal of 140 tons of granite setts, 95 tons of steel and 50 tons of soil. Fifty-two tons of new foundation had also to be laid, but the whole work was completed by eight o'clock next morning.

LECTURING recently before the British Export Society, Mr. A. C. Rouse, head of the American Section of the F.B.I., said that in his opinion tariffs were imposed by the countries of Latin America more for revenue than for protective purposes, and he did not anticipate that the growth of local industries would be harmful to British industries, except in Brazil and in isolated lines in other countries.

A NOVEL holiday pay plan has been started at Fort Dunlop from the present month until the end of July. The complete period is divided into six sections of four or five weeks, for each of which an operative becomes entitled, where no time has been lost, save by certified sickness, transport breakdown or leave of absence obtained from the management, to one-sixth of the holiday week pay, calculated on the rate paid to the particular worker in the middle of July next. The plan, which has been advocated from time to time during the past few years by the Factory Council and Works Committees, is looked upon as being of mutual benefit to employers and employed.

NO fewer than seven new harbours of varying sizes and importance are now in course of construction in the Faroe Islands. At Thorshavn, the capital of the islands, work on a new harbour, comprising two quays protected by a breakwater 600ft. long, is well advanced, and is expected to be completed at the end of next year, the estimated cost being over 2,000,000 kroner (about £80,000). A smaller harbour, which is nearing completion at Skopen, the north-west point of the Island of Sandoe, consists of an outer and inner mole, which will afford shelter for fishing craft of small tonnage. It will also serve as a lifeboat station and emergency anchorage for vessels in danger at a particularly treacherous part of the coast. The other harbours in course of erection are at Midvaag and Soervaag, on the Island of Vaagoe, and at Tvoraa, Kvigig, and Hov. All the harbours are being constructed of the grey rock typical of the Islands.

THE TWIN-SCREW GEARED-TURBINE ORIENT LINER ORONSAY

JOHN BROWN AND CO., LIMITED, CLYDEBANK, BUILDERS AND ENGINEERS

(*For description see page 185*)

AGENTS ABROAD FOR THE SALE OF

The Engineer

BUENOS AIRES.—MITCHELL'S BOOK STORE, 576, Cangallo.

CHINA.—KELLY AND WALSH, Limited, Shanghai and Hong Kong.

EGYPT.—CAIRO EXPRESS AGENCY, near Shepheard's Hotel Cairo.

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DEATH.

ON the 2nd Feb., at "Stackpole," Festing-road, Southsea, LEWIS GEORGE DAVIES, of the Royal Corps of Naval Architects, late Civil Technical Assistant, Portsmouth and Devonport Dockyards, in his 74th year.

THE ENGINEER.

FEBRUARY 13, 1925.

Marine Oil Engine Progress.

THE post-war development of the motor ship and the marine oil engine in Great Britain has been characterised by the construction of a large number of engines of widely varying types, which, built either to British or continental designs, yet bear the imprint of British marine engineering practice. But as yet we can see little tendency towards any finality in design. Engines of the common four-stroke and two-stroke single-acting types and the opposed-piston type have all given good results, while a new factor has recently been introduced by the advent of the double-acting engine. We have reason to hope that before the end of the year running experience will have been obtained with both four-stroke and two-stroke motors, working on this principle. Briefly, that is the point at which we have arrived in the fourteen years that have passed since the Vulcanus opened a new era in marine propulsion. It is frequently of advantage to look backwards upon the steps by which we have secured a position. Progress then presents itself to our eyes as a curve stretching from zero to the point at which we stand, and we may without excessive daring indulge in a moderate degree of extrapolation and see wdither it is leading us. Such a review it was that Sir Westcott Abel laid before his audience in the presidential address which he delivered on Tuesday last to the Institution of Marine Engineers.

With his wide practical knowledge, Sir Westcott singled out "economic efficiency" as the criterion wherewith to judge ships and their performances. Such a term must necessarily embrace the essential factors of first cost, including interest and depreciation, maintenance and operating charges, cost of fuel and lubricating oil, and, what is most important of all, reliability of operation. This last factor is admittedly difficult to assess, but helpful evidence was given in Sir Westcott Abel's own paper read before the North-East Coast Institution of Engineers and Shipbuilders in 1921 on "Sea Casualties and Loss of Life," wherein it was shown that within the period 1890 to 1912 the casualties at sea arising from machinery defects had been reduced from about nine per cent. to four and a-half per cent. But this very gain in the reliability of steamships may have delayed the introduction of the motor ship. The first ocean-going vessel to be propelled by oil engines was the Vulcanus, built by Werkspoor in 1910, in which a 500 brake horse-power six-cylinder engine was installed. In the period up to 1914 other cargo vessels of moderate size, with engines of the Burmeister and Wain type, were built, but it was not until the restoration of peace and the revival of industry that any appreciable tonnage of British motor shipping took the water. During 1920 seven ships were built in home yards, and each succeeding year has seen an increasing number, until last year the number reached forty-three, whilst in the last quarter of 1924 the number of motor ships under construction in the whole world more than equalled the number of steamships on order. No less remarkable is the increase in the size of engine units during the period under review. To-day cylinder diameters of large engines are just twice the 15½in. diameter cylinders of 1910, and units of 4000 brake horse-power on eight cylinders are built on the Sulzer two-stroke single-acting principle, whilst the new Burmeister and Wain four-stroke double-acting engine develops 6750 brake horse-power in six cylinders, and in Germany a nine-cylinder engine of 15,000 brake horse-power is being built on the M.A.N. two-stroke double-acting principle. The reliability and manœuvring capacity of the marine oil engine has also been improved and established during the last few years, and it is now not less trustworthy than the steam engine. We cite as a proof of this statement the recent decision of Lloyd's Register of Shipping to institute a special examination of the machinery every four years and a modified survey after each intervening two years, instead of the annual survey which at one time was insisted upon. If machinery reliability be one of the chief factors in the economic efficiency of a ship, cost of running is another of not less importance. Here, again, the oil engined vessel has shown results more than equal to that of the best steam practice. Some figures quoted by Sir Westcott Abel may be used to illustrate this point. If a 2000 brake horse-power marine installation be taken as an example, then a triple-expansion steam engine of that power with a coal-fired boiler would use about 32 tons of coal per day, and would have an overall brake thermal efficiency of thirteen per cent. With a steam turbine and coal-fired boilers, the amount of fuel consumed might be lowered to about 20 tons, with a corresponding efficiency of twenty per cent. Better figures would be obtained with an oil-fired boiler. As against these figures, the Diesel oil engine of the same power would use not more than 8 tons of oil fuel per day, giving a saving over the steam engine of 24 tons of fuel. The efficiency of the oil engine, it is stated, would vary from thirty-seven to forty-one per cent., according to the type of engine used. It is of interest to note that on an actual voyage a vessel propelled by a Scott-Still engine of the same power used about 7½ tons of fuel per day, corresponding to a fuel consumption of 0.350 lb. per brake horse-power-hour, while an almost similar figure is claimed for the Doxford opposed-piston engine. This comparison shows the relative fuel saving in the case of the cargo vessel, but no less significant are the results obtained with large motor liners. On the recent maiden voyage of the 17,500-ton quadruple-screw motor liner Aorangi, with Fairfield-Sulzer engines of 13,500 brake horse-power, which was described in our early issues of the present year, a fuel consumption of 0.45 lb. of fuel for all purposes was obtained for an average speed of about 17 knots. It is difficult to make actual comparisons with a similar steam vessel, but one of the best recent performances of a geared turbine ship with oil-fired boiler and electrically driven auxiliaries was obtained during the high-power trial of the 20,000-ton Orient liner Orama, when a consumption of 0.785 lb. of oil fuel per shaft horse-power was recorded. In this connection it is a somewhat sobering reflection that the amount of boiler oil which is burned in the furnaces of our large Atlantic liners would, if it could be utilised in the cylinders of marine oil engines, go far to provide fuel for the whole of the present world fleet of motor ships of about two million gross tons total.

But it seems likely that the largest step in fuel economy has been taken, and that further gains will only be obtained with difficulty and perhaps added complexity. In any case, they are unlikely to affect the cost of marine transportation in the direct way which the reduced fuel consumption of the motor ship, with smaller bunker space and greater ease of fuel handling, has already done. Some improvement may, no doubt, be made in the direction of reducing the weight of machinery and the space occupied, but such gains will not be

economical if they are purchased at the price of simplicity of construction and ease of maintenance. Moreover, they—space and weight saved—can never be more than a small proportion of the total weight of the installation. A more fruitful direction of improvement would be the simplification of the main engine and the reduction of the number of auxiliaries which are at present required in motor-propelled vessels. In his plea for the maximum simplicity, Sir Westcott Abel suggested that in the development of every discovery little devices are constantly being added which tend to cover up and mask the original production. He put the question whether, after a time, progress is not better served by considering the problem afresh and embodying these developments in a simplified form in the body of the mechanism itself. It is a curious thing that recent oil-engine development has perhaps tended in the opposite direction. The first marine oil engines embodied in the main design a complete service of the necessary pumps for air, cooling water and lubricating oil services, which were either driven from the crank shaft or by levers in the usual manner of marine engines. But the modern engine has been simplified at the expense of additional auxiliaries, and is no longer self-contained. No doubt the highly efficient designs of electrically driven centrifugal pumps have contributed to this development. Another simplification is seen in the use of the turbo-blower for supplying scavenging air. The development of the scavenging turbo-blower in Great Britain has been retarded by the difficulty in obtaining a high-speed electric motor suitable for the work, but it is to be hoped that this deficiency will be overcome in the near future, and that shipowners and builders will not neglect experimental work in the direction of the use of supercharging blowers, which principle appears to offer much promise.

There is no doubt that considerable progress is possible by the reduction of the cost of the auxiliary machinery, both in the engine-room and on deck. At the present time it is customary to fall back on standard designs of pumps and deck machinery whenever steam is available in a motor ship, whilst the auxiliaries of recent geared turbine steamships are, with few exceptions, entirely electrically driven and show considerable saving in operating costs, although the first cost is probably higher. We are sure that much could be done towards reducing the cost of the auxiliary machinery, by the closest co-operation of the owners, shipbuilders and auxiliary machinery makers in the preparation and carrying out of new designs. Shipowners hitherto have often hesitated to install electrically driven winches, windlasses and capstans on account of the rough and often unskilled handling of such machinery by the deck hands. Maximum simplicity of control would remove such objections, and despite the improvement already made there is still room for progress in this direction. We have touched upon only a few of the possible lines of progress, but advance in these directions would certainly improve the position of the British motor shipbuilder, and would not only establish increased confidence in the motor ship amongst British shipowners, but would also influence orders from foreign owners.

The Heaviside Layer.

THE death of the famous physicist and electrician, Mr. Oliver Heaviside, has, if anything, augmented the interest in the semi-conducting layer which is supposed to exist in the upper regions of the atmosphere. While Heaviside was not the first to surmise that there was an ionised layer some 50 or so miles above the earth's surface, he was undoubtedly the first to associate it with radio communication. It was stated in a lecture delivered in 1913 that F. G. Fitzgerald in 1893 first suggested that such a layer existed, but it is highly improbable that even at that date the theory was by any means new. In any case the fact remains that Oliver Heaviside helped the mathematicians out of a great difficulty when he pointed out that in all probability the electromagnetic waves were bent round the earth by a layer of the kind. It was originally supposed that wireless communication over great distances would be impracticable because the waves would shoot off into space. Mathematicians showed that it would be quite impossible to send messages between, say, England and Canada, but they put into their calculations an assumption which was not in accord with physical facts. The experiments of Mr. Marconi demonstrated, as everyone knows, that the refraction or bending of the waves along the curvature of the earth was very much greater than the mathematicians expected, and the most commonly accepted explanation of this discrepancy between theory and practice is that which was suggested by Oliver Heaviside, namely, that a certain distance above the earth the atmosphere has different electrical properties from those near the surface, with the result that the waves are enclosed between two concentric surfaces and are compelled to bend round the globe.

It is perhaps not generally realised what an enormous amount of attention has been given to this theory, which is not only used to explain why long-distance transmission is possible, but other things besides. Failing to find any explanation in the explored regions of the atmosphere for the various strange things that happen in wireless work, scientific people very naturally turn to the unexplored regions of space. It is very doubtful if Oliver Heaviside ever imagined that his theory would lead to so much discussion or that it would be used in attempts to solve other wireless problems besides the one to which he applied it. Quite a number of eminent men, including Sir Oliver Lodge, Dr. Lee de Forest, and Dr. Fleming support it, although there are differences of opinion as to how the upper semi-conducting layer is formed. Some doubt, for instance, that the atmosphere can be ionised by the sun's rays, and Dr. Fleming has suggested that the layer might be produced by the collection in the upper atmosphere of charged dust particles projected from the sun. Another scientist who has doubted the ability of the sun to ionise the upper atmosphere is Professor Guinchant, of Bordeaux. The arguments of the Professor have, however, been taken up by Sir Oliver Lodge, who points out that the aurora provides ample evidence of ionisation in the upper atmosphere. There are others who contend that the Heaviside layer does not exist at all. For instance, Major-General Squier, the Chief Signal Officer of the United States Army, who argues that it is logical to assume that the earth being a conductor can guide and cause the waves to follow its curvature much as the conducting wire does in his well-known system of "wired wireless." General Squier also contends that Heaviside never suggested the reflecting theory of the upper layer, but merely conceived the earth to be one conducting medium and the upper layer the other. From an article written by General Squier in 1923 it would appear that he also doubts whether Oliver Heaviside ever attached much importance to the ionised layer theory. The influence of daylight on radio transmission—one of the main arguments in support of Heaviside's hypothesis—he considers to be applicable to the gliding wave theory, because the conductivity of the earth is profoundly affected by sunlight. We do not think that many of the leading authorities will agree with these views. It is stated by the author of an article on Sir Joseph Larmor's paper on "The Bending of Wireless Electric Rays," read before the Cambridge Philosophical Society on October 27th, that Larmor considers from a recent study of Watson's diffraction theory that it seems unlikely that the ground can take any appreciable part in the transmission. At the last meeting of the Institution of Electrical Engineers the President was understood to say, when referring to the death of Mr. Oliver Heaviside, that he had been told that short-wave wireless experiments had established the fact that there actually is an upper semi-conducting layer. Some scientific men do not seem to have much doubt about its existence, but it will be news to many that its existence has been definitely proved. Although attempts have been made to establish its presence by experiment, they have not led to definite results. It has actually been proposed within quite recent times to construct a model of the earth, about one-thousandth full size, and with a sliding Heaviside layer, capable of being put into action as required, so as to clear up some, at any rate, of the mysteries connected with wireless communication. One of the most troublesome phenomena of wireless transmission to explain is fading. As all wireless experimenters are aware, good signals from a distant station often gradually decrease in strength and sometimes become so weak that they cannot be read at all, yet they may afterwards increase again and become more powerful than they were in the first instance. The simplest and most straightforward answer to the queston "Why do signals fail?" is that given by Captain Eckersley, namely, "I do not know." He generally adds, however, that it is certainly not attributable to any imperfections of the British broadcasting stations. But there is a theory which he often describes in simple language and which introduces Mr. Heaviside's layer. Briefly, it is that, owing to the influence of sunlight, the atmosphere below the permanently ionised layer is made a semi-conductor every day and a good insulator every night. When night sets in and the lower atmosphere loses its conducting properties the path for the waves is clear and the surface of the Heaviside layer is supposed to be more or less clearly defined. The waves, and especially short waves, can then travel freely. If we imagine a transmitting and receiving station situated a considerable distance apart, some of the waves, according to this particular theory, are supposed to pass from the former to the latter direct, but others hit the Heaviside layer and are reflected from it and are added to the waves that are taking the direct course. It is as though the layer were a great mirror, and in the language of Captain Eckersley, as it turns and changes and moves uneasily in its sleep, so the signals are reflected more or less and fading occurs. If this theory were true there should be no fading in the day time, but the signals should be uniformly weaker, and generally speaking this is found to be the case. This explanation is, of course, framed on popular lines, and those who require more detailed and more technical and rather different explanations can easily find them, one of the best, in our opinion, being that written by Mr. O. F. Brown and published by the Radio Research Board in 1923.

It is said that Oliver Heaviside was very dissatisfied with the way in which his work was received. True, his discoveries brought him little financial reward, owing, no doubt, to the fact that he was not a business man. But if he ever took the trouble to read even a part of all that has been written about the Heaviside layer, he must surely have realised that if he had done nothing else, he had certainly succeeded in causing a very great stir in the scientific world.

The Comptroller of Patents.

IN the issue of *Nature* for February 7th there appeared an interesting article on the future of the British Patent Office. It foreshadows the early retirement of the present Comptroller of Patents and discusses the qualities that should be sought for in his successor. It concludes with these words: "It is earnestly to be hoped that no candidate will be even considered who does not combine with his experience of patent practice a thorough training in physical science. It should be an absolutely inviolable principle that an essentially scientific staff should have a man of science at its head." We venture to suggest that in its devotion to science, our contemporary has been led to overlook the nature of much of the work of the Comptroller of Patents. It is true that from time to time questions connected with highly scientific problems come before him, but the bulk of the inventions which pass through the Patent Office are rather of a technological and engineering description than of a scientific one. We would not be understood to be pushing the claims of an engineer in opposition to those of a scientist, if we express the view that, on the whole, an engineer with a broad training and a scientific mind is more likely to fill the post appropriately than a man of science who has necessarily had to specialise and whose sympathy with technology might be inconsiderable. We believe that it has not been the custom in the past to make the appointment from the examining staff of the Patent Office, but since there is at present at least one man on the staff who would be quite capable of filling the office of Comptroller with ability and distinction there is no reason that we know of why a departure should not be made from former practice. An appointment from the existing staff would have the great advantage that the new Comptroller would be conversant with the details of management and practice at the Patent Office, and, no less important, with the handling of the Treasury and other Departments of State. It was suggested in *Nature* that a barrister from the Patent Bar might be induced to accept the position if the salary were raised to a point at which it would be sufficiently tempting. According to Whitaker the salary now paid to Mr. Temple Franks is £1500, and it is exceedingly improbable that any material advance on that figure will be made. There are but few barristers with such qualifications as our contemporary has in mind, and as those that exist are in enjoyment of very large incomes, it is unlikely that any one of them would be tempted to leave the Bar for His Majesty's Patent Office.

Wire Flattening.

IN the series of articles on wire-drawing and wire-working machinery, which was concluded in our issue of December 19th last, some reference was made to the flattening of wire, by means of rolling, for the production of thin strip, and our remarks were chiefly confined to the problem of producing rolls which will stand up to this arduous service. The subject is, however, of such importance that we revert to it here, since we are now able to give detailed information concerning the general principles involved and machines employed. Flattened wire is used for a great variety of purposes, and ranges from the extremely thin tempered steel used for the reeds of musical instruments, through the comparatively stiff wire for scratch brushes, to heavy "stuff" a ¼in. or more in thickness.

It is, of course, quite possible to draw rectangular wire through dies in the same way as the ordinary

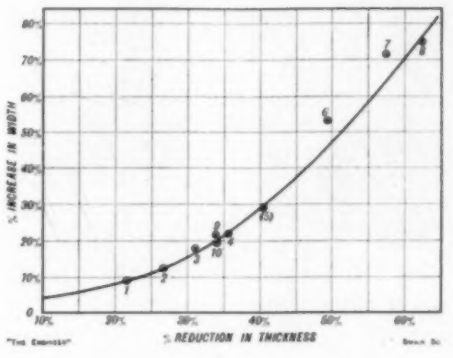


FIG. 1

round wire is drawn. In fact, sections approaching a square in proportions are generally produced in that way, but when the thickness is small in proportion to the width of section the drawing operation is less economical.

Flattened wire may be required to be so thin in proportion to its width as to be more correctly described as strip, and this strip in both steel and non-ferrous metals is usually produced by cold rolling between hardened steel rolls. The class of material, termed strip, includes a very wide range of dimensions, covering as it does any comparatively thin metal which is produced in long continuous lengths, and its width may be anything from ¼in. or less up to 12in. or even 18in. The difference between wire flattening and strip rolling proper lies merely in the form of the metal before the rolling operation. As mentioned above, wire flattening is rolling from the round section, while strip rolling starts with metal which has already been reduced to a rectangular section by hot rolling, casting or drawing.

In the case of steel, cold-rolled steel strip is obtained by rolling hot rolled strip, the cold rolling process merely reducing the thickness with accuracy to the required gauge. Rolling gives a bright and clean surface, and incidentally hardens and increases the strength of the metal. Copper and brass strip may be cold rolled from cast slabs, and indeed every metal or alloy requires its own special treatment. Subsequently the strip may be slit in multiple circular shearing machines into a number of narrower strips.

Rolling is the most economical method for comparatively wide strips, but for strips less than 1in. wide the wire flattening operation is preferred, especially where a smooth slightly rounded edge is desired.

Flattened wire is mainly required in steel and copper, but nickel silver and other metals or alloys are also produced in this form in considerable quantities. In all cases the material before rolling is in the form of drawn or rolled circular wire of the correct diameter to give the desired width when flattened to the required thickness. The relation between linear and transverse extension of material produced in rolling is a question which has received considerable study, but so far it has been found impossible to formulate any general rule, since transverse extension or spread depends on many conditions, all of which permit of a wide variation.

The chief factors in the problem are:—(1) The nature of metal rolled. Thus soft metals tend to spread more than hard metals. (2) The dimensions and shape of section rolled; a section approaching a square or circle before rolling will spread to a greater extent than will a flat rectangular section in which the width is great in proportion to the thickness. (3) The reduction per cent. in thickness taken at one pass. Naturally, the greater the reduction in proportion to the thickness the greater the spread. (4) The diameter of the rolls. With the same reduction in thickness the spreading appears to vary with the diameter of the rolls employed. Experiments on this subject carried out by Mr. C. E. Davies, of Messrs. Robertson's, Bedford, have indicated that the larger the roll diameter the greater the spread. See Tests (9) and (10), Table I. (5) Probably a variation in rolling speed has some effect, and even the condition of the roll surfaces has an influence, as highly polished well lubricated rolls facilitate spreading, this effect being more marked in the case of comparatively wide strip.

In Table I. there are given some figures from wire

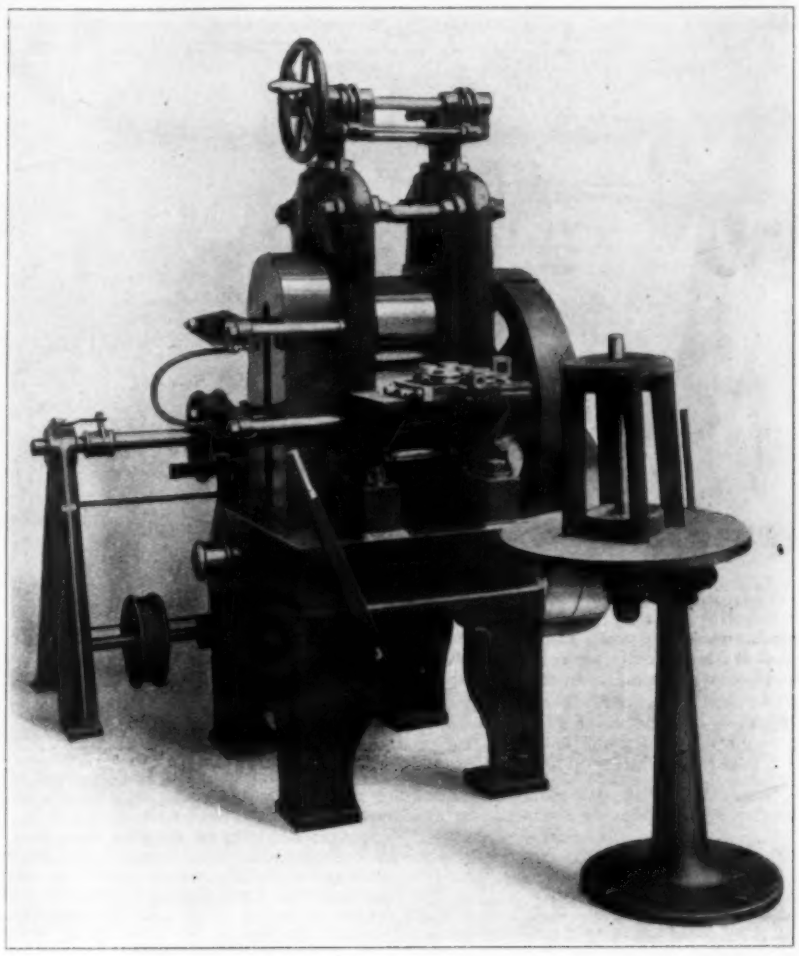


FIG. 4—9in. x 6in. WIRE FLATTENING MILL

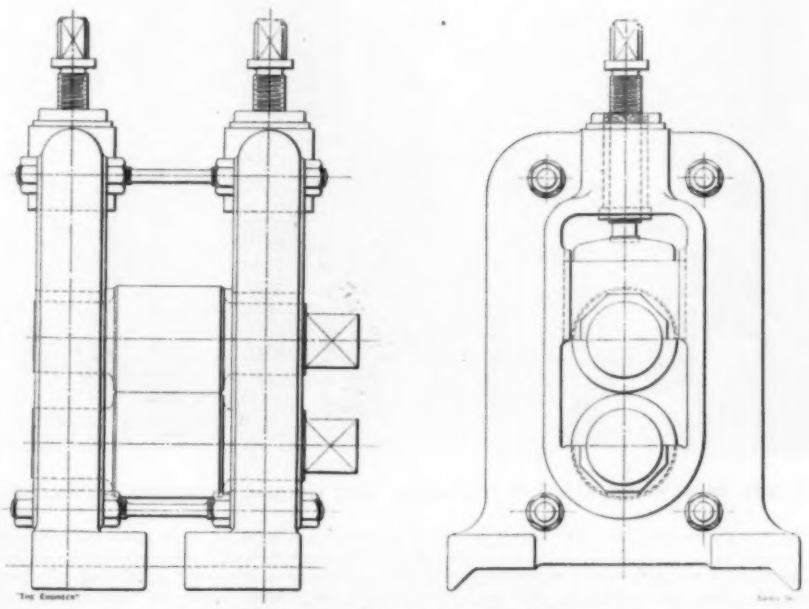


FIG. 2—GENERAL ARRANGEMENT OF WIRE FLATTENING MILL

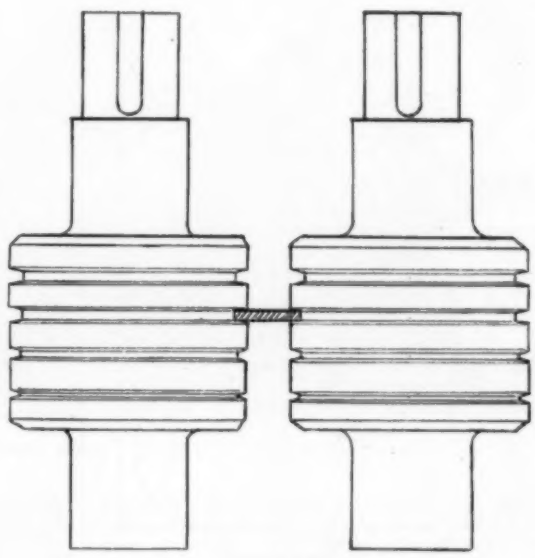


FIG. 3—EDGING ROLLS

flattening experiments, which give an idea of the amount of spread likely to occur with varied conditions, while the results are plotted in the form of a curve in Fig. 1.

Wire flattening requires essentially only a simple form of rolling mill, of which a typical example is illustrated in the line drawing Fig. 2. The machine comprises a pair of narrow-faced rolls, usually of hardened steel, running in bearings fitted in strong cast iron or steel frames. The top roll is adjustable, in order to permit the regulation of the thickness

TABLE I.

Test No.	Diameter before rolling.	Thickness after rolling.	Width after rolling.	Per cent. reduct'n in thickness.	Per cent. increase in width.	Roll dia.	Rolling speed, feet per min.
	in.	in.	in.			in.	
(1)	0.5	0.392	0.545	21½	9.0	10	104
(2)	0.5	0.368	0.559	26½	11.8	10	104
(3)	0.5	0.344	0.589	31	17.8	10	104
(4)	0.5	0.322	0.608	35½	21.5	10	104
(5)	0.5	0.297	0.643	40½	28.5	10	104
(6)	0.1875	0.095	0.287	49.5	53.0	10	104
(7)	0.2187	0.094	0.375	57.5	71.5	10	104
(8)	0.252	0.094	0.440	62.5	74.5	10	104
(9)	0.1406	0.093	0.171	33.8	21.5	9	—
(10)	0.1406	0.093	0.167	33.8	18.8	4	—

NOTES.—In all these tests steel wire was rolled. Tests (1) to (5) inclusive were made on ordinary hot rolled mild steel rod. Tests (6) to (10) inclusive being on drawn steel wire (soft, but not annealed).

rolled, by means of steel screws and spanners. Spur pinions are keyed to the roll spindles for gearing the

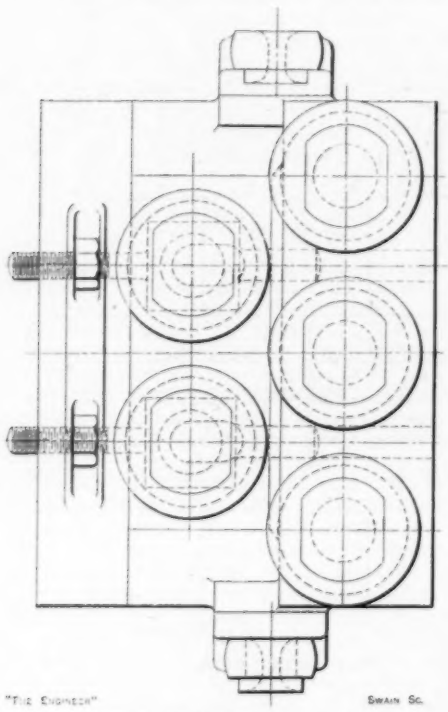


FIG. 7—STRAIGHTENING HEAD

two rolls together, and any convenient gear is provided for driving the machine. The rolls themselves must be of a special alloy steel, hardened to the highest possible degree, and finished by grinding. The hardness should be between 90 deg. and 100 deg. by scleroscope, as the rolling of round wire and narrow strip is the most severe test of the quality of a roll, and even with the best possible steel and the greatest degree of hardness the metal will wear grooves in the roll surface. On this account it is usual to alter periodically the position of rolling across the face of the roll, so as to wear the surface as uniformly as possible, until re-grinding is necessary.

Another important item is the roll bearings, and the method of lubrication, owing to the heavy pressures imposed. In the simple form of mill shown in Fig. 2 the roll necks are supported in plain open bearings with grease lubrication, and in order to prevent excessive heating of the bearings or rolls a water supply is led directly on to the roll necks.

During the last ten to fifteen years great improvements have been made in the design and construction of special mills for wire flattening work, and the series of standard mills built by W. H. A. Robertson and Co., Limited, of Bedford, are good examples of modern practice in this class of machinery. These mills are made in standard sizes with rolls from 4in. diameter to 12in. diameter. Fig. 2 represents a typical example. It shows a Robertson wire flattening mill, with rolls 9in. diameter, 6in. face, intended for heavy work.

The hardened steel rolls are accurately ground to within 0.00025in. of exact concentricity, and are carried in phosphor bronze bearings provided with an efficient lubricating system. The top roll is adjusted by steel screws, working in hammered iron nuts secured in the top of the roll frames, the two screws being simultaneously adjusted by a hand wheel at the side, through machine-cut worm gearing. The roll pinions are keyed to the roll spindles, and are made with a special form of tooth to provide for the necessary variation in the distance between the roll centres and to maintain at the same time accurate rolling contact.

The rolls are bored centrally, and are provided with water-cooling connections to maintain a moderate and uniform temperature. These water connections and fittings are seen in the left-hand of Fig. 4. The mill is arranged for a belt drive, with fast and loose pulleys on the driving shaft, which is geared to the lower roll by a pair of machine-cut spur wheels.

In producing flattened wire, it is necessary that the finished material should be taken off by a special winder, as the wire must be drawn away from the rolls squarely, while it must be wound in even layers to prevent damage to its section. Part of the coiler can be seen in the background of Fig. 4, which also shows how the winder is driven, by belt, from a small pulley on the end of the main driving shaft. A general view of this coiler is given in Fig. 5. The wire is wound on to a double-flanged reel of the collapsible type, and the drum spindle is given a traversing motion, by means of a special double-threaded worm, in order to wind the strip uniformly between the flanges.

A more elaborate form of coiler is shown by Fig. 6. It is fitted with a cam-operated traverse, and provided with adjustments both for the rate of traverse to suit varying widths of strip, and for the total length of traverse, to suit different widths of coil. The rate of traverse is varied by means of change wheels, and the length of traverse by altering the position of the cam lever fulcrum. Usually, three holes are provided in the fulcrum bracket, giving three alternative positions for the pin on which the cam lever rocks.

Another important accessory is the straightening head, shown at the inlet to the rolls in Fig. 4. This device is necessary for straightening the round wire as it enters the rolls for the first flattening reduction and consists of five hardened steel grooved rollers, arranged as shown in Fig. 7. Two of the rollers are adjustable, while two guides with interchangeable steel bushes, to suit the diameter of the wire being

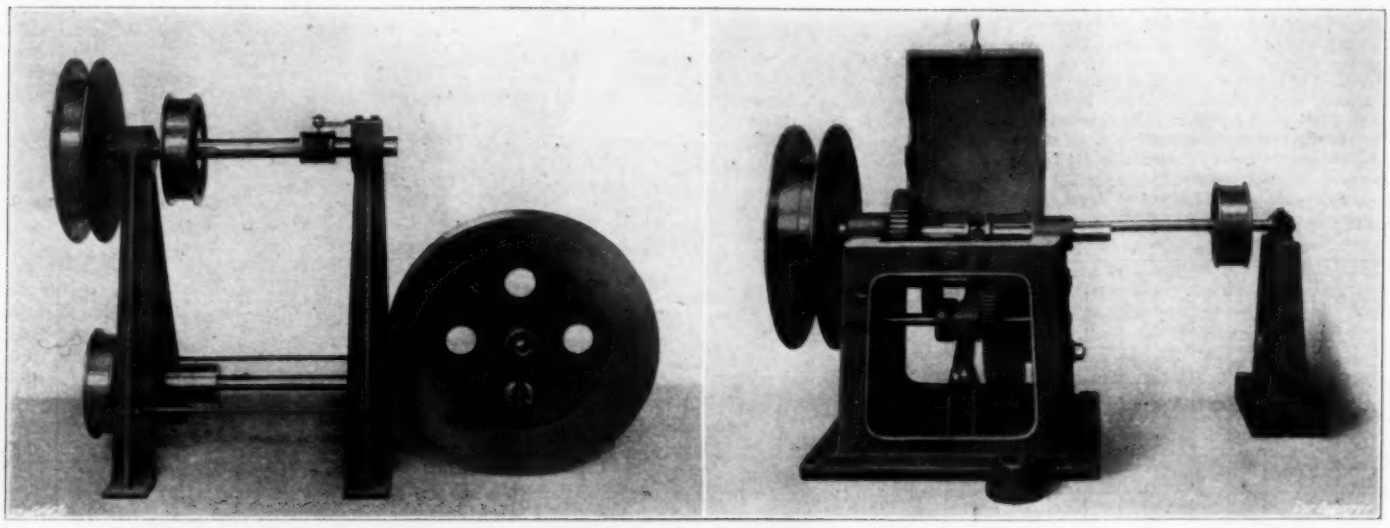


FIG. 5—SINGLE COILING STAND

FIG. 6—HEAVY COILING STAND

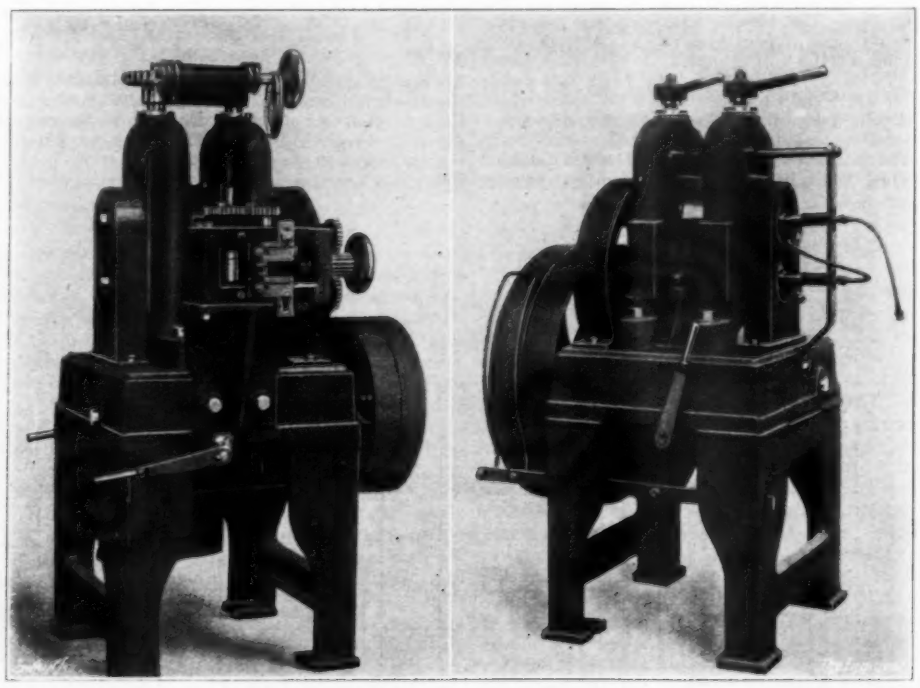


FIG. 8—MILL WITH EDGING ROLLS

FIG. 9—MILL WITH SEPARATE ADJUSTMENT FOR BEARINGS

used, are arranged at either end of the head. This straightening head is, of course, only required for the first pass. Even after the first pass, when the wire is already flattened, it is necessary to employ guides at the inlet to the rolls, to ensure the feed being truly at right angles to the axes of the rolls. A guide bracket for this purpose is shown to the right of the straightening head in Fig. 4; when this guide is required the straightening device is easily removed from the supporting bracket. The guide bracket has a square hole, in which guide strips can be secured, and is slid into position in line with the pass through the rolls.

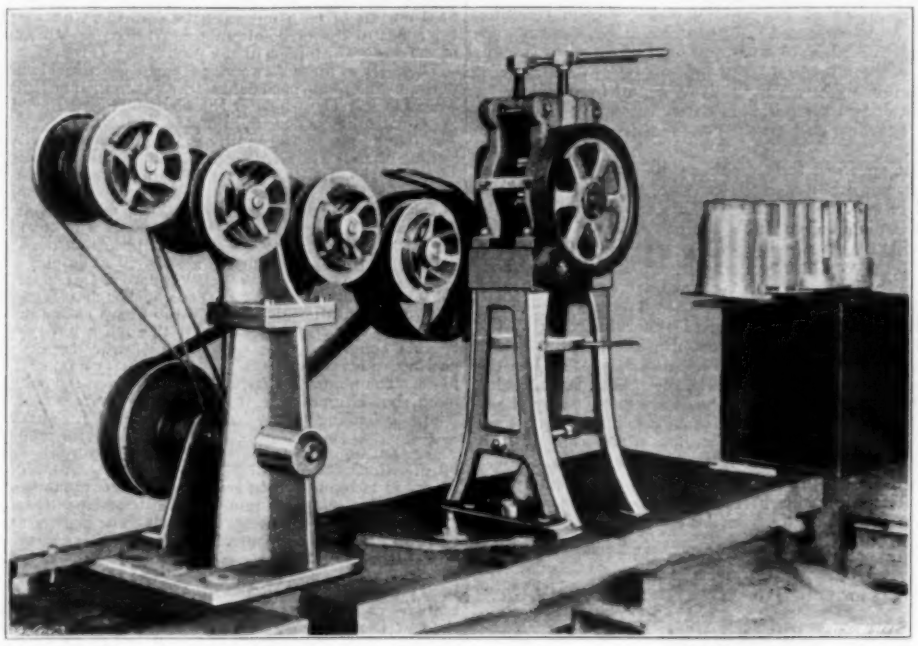


FIG. 10—SMALL FLATTENING MILL FOR FOUR WIRES

When a high degree of accuracy in width and a specially smooth and well-finished edge is required, the edging attachment shown in Fig. 8 is fitted to the mill. This mill is smaller than that already described, and has rolls 6in. diameter, 2½in. face. The edging attachment consists of a pair of small hardened steel rolls, with their axes vertical, and provided with a series of shallow semi-circular or rectangular grooves, graduated to suit various thicknesses of strip.

The edging rolls are fitted on the inlet side of the main flattening rolls, and consequently cannot be employed until after the wire has been reduced to a flat section. Edging is generally accomplished during the last or last two passes, and as the action of the edging rolls tends to thicken the edges of the strip slightly the last pass through the flattening rolls must be light—just enough to equalise the thickness of the strip and to provide sufficient tension to draw the strip through the edging rolls.

In order to start the strip through the rolls for an edging pass, either the pressure on the edging rolls must be applied after the leading end of the strip has been gripped by the flattening rolls, which means scrapping a few inches of the leading end of the strip, or the strip must be fed through the edging rolls by turning them by means of a hand wheel keyed to the spindle of one of the vertical rolls. This hand wheel is not shown in Fig. 8, but is now always fitted and provides the best means of starting the pass. With power-driven edging rolls, such as those fitted to the mill illustrated by Figs. 11 and 12 and described hereafter, this difficulty does not arise.

The edging rolls, of which a line drawing is given in Fig. 3, are not generally directly driven, but are geared together by machine-cut steel pinions. One roll is adjustable by means of a hand wheel and gearing to suit the width of strip required, and hardened strip guides, adjustable both vertically and horizontally, are fitted on the entry side.

Two further types of flattening mill are represented in Figs. 9 and 10. The first has rolls measuring 6in. by 2½in., and has a separate spanner adjustment to the bearings for the top roll.

A still smaller pattern is shown in Fig. 10. In this case the rolls are 4in. diameter by 3in. face, and the machine is of exceptional interest, as it is provided with a special four-reel coiler, so that four wires can be rolled simultaneously. This method of increasing the rate of production is only suitable for very thin and narrow strip. Wire about 0.05in. diameter can be flattened to 0.005in. thick at one pass through these rolls at a rolling speed of 100ft. per minute.

Heavier gauge wires require several passes to reduce them to thin strip, but modern wire-flattening mills are capable of taking very heavy reductions per pass. A Robertson mill, with rolls 6in. diameter, has been tested on flattening ¼in. diameter mild steel, and a 50 per cent. reduction in thickness was affected at each pass. The wire was reduced to 0.0156in. thick, without annealing, in four passes, the first pass being from ¼in. diameter to ¼in. thick, the second from ¼in. to 1/16in., and so on.

The maximum "pinch" or reduction in thickness at the first pass is limited by the power of the rolls to grip the metal, which depends on the roll diameter. About ¼in. reduction in thickness is the limit for rolls of 6in. diameter, unless the end of the wire is flattened before it is inserted between the rolls.

The best relation of roll diameter to size of wire flattened naturally depends on many factors, such as the total reduction required, the maximum pinch, and the degree of accuracy demanded. Table II. indicates the maximum size of wire which can be conveniently flattened between rolls of standard dimensions, taking reasonably heavy reductions.

TABLE II.

Roll diameter.	Size of wire.	Horse-power.
4in.	8 S.W.G.	6
6in.	4 S.W.G.	10
8in.	5/32in.	12
9in.	7/32in.	15
10in.	¼in.	18

The power absorbed in wire-flattening varies with the size of the rolls, rolling speed, reduction taken, and the nature of the metal rolled, and consequently cannot be stated generally. Approximate figures for the power required are, however, given in Table II., and are based on a maximum rolling speed of 100ft. per minute.

At the present time practice tends towards employing rolls of larger diameter than used previously for any particular size of wire, for not only is it possible to take heavier reductions, thereby reducing the number of passes required, but on account of the greater rigidity of the heavier mill a higher degree of accuracy is obtained in the finished product. Rolls 9in. and 10in. diameter are now very generally in use, and for flattening rod of large diameter heavy mills with rolls 12in. diameter have been installed.

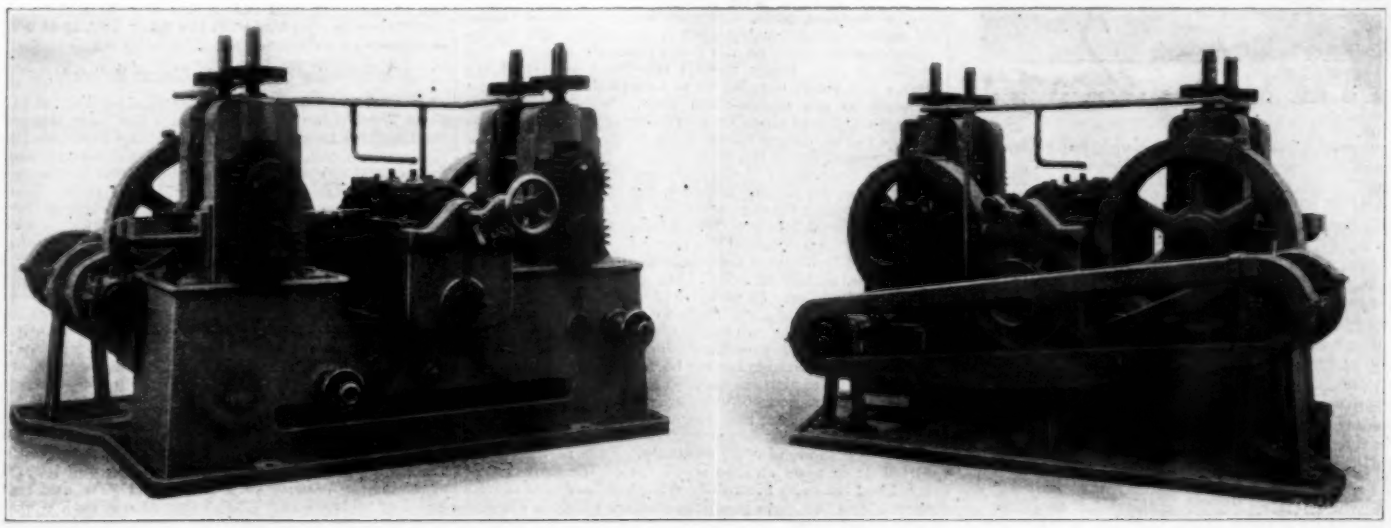
As will be readily understood, any spring in the rolls or stretch in the roll frames will, in conjunction with vibration, cause the strip to be wavy—that is, varying in both thickness and width.

There is also the important question of rolling speeds. Generally 70ft. to 80ft. per minute is adopted for rolls on this class of work, although 100ft. per minute and even higher speeds are not uncommon. The disadvantage of high speeds is the vibration that they introduce, which results in a loss of accuracy and uniformity in the thickness of the rolled strip, while the heating of the rolls and their bearings also causes trouble. Both these defects may be eliminated by employing rolls amply large for the dimensions of wire rolled, as for the same peripheral velocity the speed of rotation is reduced, with a corresponding reduction in vibration. The greater bearing area and increased area of radiation surfaces also prevent an excessive rise in the temperature of the bearings.

In all cold rolling mills the problem of maintaining a reasonably low bearing temperature is a serious one, on account of the heavy loads which the roll bearings are required to carry, and with heavy pressure any increase in speed is naturally likely to cause bearing trouble, besides which the progressive heating of the rolls results in a variation in thickness of the rolled strip.

In order to give some idea of the magnitude of the pressure on roll bearings in wire flattening, it may be mentioned that the mill with 6in. diameter rolls previously described, when flattening mild steel wire from ¼in. diameter to strip ¼in. thick at one pass, would be called upon to impose a pressure of about 6 tons on the metal in contact with the rolls. This load must, of course, be carried by the two bearings supporting each roll.

To obtain a reasonable output from a wire-flattening mill it is obviously necessary to make as heavy reductions as possible at every pass, and also to roll at the highest possible speed, for, with the comparatively small dimensions of strip produced by such mills, the weight per foot of material rolled is correspondingly small, and a step in advance in this direc-



FIGS. 11 AND 12—TANDEM TWO-PASS MILL WITH EDGING ROLLS

tion has been effected, within recent times, by improving methods of lubrication for the roll bearings and by internal water cooling of the rolls themselves, which has permitted higher speeds without detriment to the quality and accuracy of the finished product.

Another modern development just coming into vogue in this country for wire flattening and strip rolling is the tandem mill. Taking, for example, the reduction from ¼in. diameter rod to the 1/64in. thick flat previously mentioned, if four reductions are required, the material must be passed four times through the rolls, and for each pass it has to be coiled, removed from the coiler drum, and placed on a swift or unwinding reel for the next pass. The total net rolling time per ton for such a process may be some forty-eight hours. If, by arranging two mills with their rolls in line with one another, the strip can be passed through the two pairs of rolls simultaneously, and coiled only after the second pass, the total reduction can be accomplished in the equivalent of two passes, and the total rolling time may be reduced to about seventeen hours. There is also the saving in handling the coils twice between passes. Incidentally, with the tandem mill the output is further increased, as compared with the single pass mill, as the finishing rolls have necessarily to run at a higher speed than that of the roughing rolls, on account of the extension of the material. As in all continuous rolling, means must be provided for adjusting the speed ratio between the two pairs of rolls. Mills operating on the

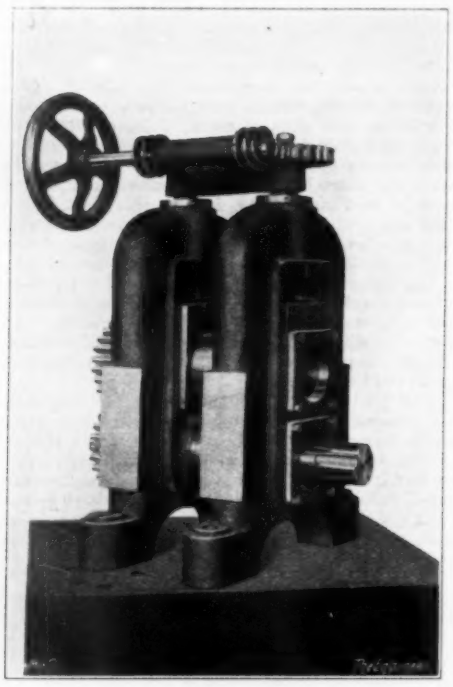


FIG. 13—MILL FITTED WITH ROLLER BEARINGS

tandem principle are frequently employed in America, but have only very recently been introduced into this country.

A mill of this type built by Messrs. Robertson to designs furnished by the Torrington Manufacturing Company, Torrington, Connecticut, U.S.A., with which firm the Bedford company is associated, is illustrated by Figs. 11 and 12. This mill is really three mills in tandem, for besides the main roughing and finishing rolls, a pair of power-driven edging rolls is mounted between the two main roll stands, so that at one pass the wire is flattened through two reductions, and is also edged. For many classes of flattened wire this single process is sufficient to finish the material.

The machine, it will be seen, is self-contained on one bed-plate. Each pair of rolls is driven by machine-cut spur and chain gearing from a main driving shaft, which may itself be driven either by belt, from line shafting, or by a pitch chain from an electric motor. The driving gear is best illustrated by Fig. 12, in which the main shaft is shown on the right. On this shaft there is mounted any proper means of driving, such as a belt pulley, chain sprocket or gear wheel. The long chain drive shown prominently in Fig. 12 connects the main shaft with the driving shaft geared to the finishing rolls at the left-hand end of the mill; while the shorter, inner, inclined chain drive transmits the power to the edging rolls.

Neat welded steel guards are provided to cover all the chain and spur gearing.

The roughing rolls are directly geared to the main shaft, but the edging rolls and the finishing rolls are driven through multiple plate friction clutches, which may be adjusted by means of the hand wheels, that are seen projecting from the bed-plate in Fig. 11. In this way the speed of these two pairs of rolls may be varied, by allowing more or less slip in the clutches, thereby providing for the elongation of the rolled metal. Sufficient variation in speed can be obtained to allow for the elongation resulting from any common reduction in thickness.

The edging rolls are driven by bevel gearing, which is enclosed in a gear-box that provides effective lubrication. The two rolls are adjusted in the horizontal direction to suit the width of strip rolled by a hand wheel geared to screws which adjust both rolls simultaneously. The edging rolls themselves are of hardened steel, and are provided with several grooves to suit different gauges of strip. They have means of vertical adjustment, so that any one of the grooves may be brought into line with the metal as it passes from the roughing to the finishing rolls.

Adjustable guides at the entry to the roughing rolls and between the finishing and edging rolls are fitted. The bed-plate is designed to form a reservoir for waste oil and to prevent oil or other lubricant from flowing on to the mill floor and foundation. A chain-driven oil pump is fitted to supply oil to the roll bearings and to the rolled strip as it enters the rolls.

The speed of the finishing rolls may be as high as 180ft. per minute, so that the production from such a mill is very considerable. This type of mill is built with rolls 8in. or 10in. diameter, and is generally provided with a coiler of the type shown in Fig. 6, which may be belt or chain driven from the mill.

Another recent improvement introduced by Messrs. Robertson in the design of wire-flattening and strip rolling mills is the fitting of roller bearings to the necks of the rolls. After consultation with the Skefko Ball Bearing Company, which has co-operated in the necessary experimental work, the S.K.F. self-aligning double-row roller bearing has been adopted by them, and the heavy losses in bearing friction have been considerably reduced. A saving of 30 to 50 per cent. of the power absorbed by a mill has, we understand, been obtained in this way. Fig. 13 shows a stand of 6in. flattening rolls fitted with roller bearings of this type.

South African Engineering Notes.

The Vaal River Pumping Plant.

AT a meeting of the South African Institution of Engineers, held during the past session, a paper on "The Vereeniging Pumping Plant of the Rand Water Board," was read by Mr. Mason, who was associated with the late Mr. W. Ingham—who, it will be remembered, died suddenly a short time back—in the construction of the Vaal River barrage. The river intake station building is constructed of reinforced concrete and consists of eight compartments arranged in pairs. The water enters the first series of compartments through penstocks operated from above, the openings being protected by removable grills of heavy iron bars. Removable fine copper gauze screens are also inserted in the front compartments between the grills and the pump suction. The central wall is of water-tight construction and is carried up to the full height of the substructure—53ft.—which is 6ft. above the highest known flood level at this point. The effect of this water-tight wall is to preserve dry compartments for the chambers containing the pumping plant. The eight compartments are for the installing of the four electrically driven vertical-spindle pumping units, each unit being capable of raising six million gallons a day against a head of 86ft. to the sedimentation tanks at the main pumping station. The suction is 19ft. below normal top-water level and the pumps are direct coupled to the vertical-spindle motors situated on the engine-room floor. This arrangement ensures the pump chamber remaining dry with a flood of 6ft. above the highest known flood level, whilst the motor would remain dry if the flood rose 3ft. further still. The principal features of the pumps are the absence of any internal bearing for the impeller, the lubrication and the manner in which the thrust is dealt with. The elimination of any internal bearings was rendered necessary owing to the very high seasonal silt contents of the water to be pumped. The whole of the mechanical thrust of the pump is taken externally on a ball race mounted at the top of the pump housing. In order to eliminate thrust troubles it was specified that each revolving portion should be capable of sustaining its own thrust and that flexible couplings should be used. The procedure adopted has proved entirely satisfactory, no trouble having been experienced up to the present. As the plant is situated right on the river bank, a considerable amount of moisture is always present in the atmosphere. In order to deal with this all the motor windings were specially impregnated with moisture-proof insulating compound after assembly. Each motor can be started or stopped and its speed varied between certain prescribed limits by means of a complete system of remote control from the main pumping station, which is situated about a mile away.

After filtration the water is stored in an underground reservoir, where it is picked up by horizontal centrifugal pumps and passed through the main condensers, chlorinated, and then stored in an open reservoir. These pumps are of the horizontal spindle type, direct coupled through flexible couplings to electric motors. The pumps have double suction inlets. The pump casing includes the base volute chamber, suction inlet and discharge outlet. The impeller, which is of phosphor-bronze, is mounted on a 2¾in. diameter steel shaft. On the motor side, where the shaft passes through the casing, the water is sealed off by means of a packed gland fitted with a water seal from the delivery main, while the bearing proper is carried on an extension of the end cover. The other end of the shaft is carried in a sleeve bearing composed of a bushing in a water-tight cap bolt on to the casing, lubrication being effected by means of a Stauffer grease cap feeding through the end of this cap.

As these filtered water pumps have to deal with practically the whole of the water raised from the river, it will be obvious that the inter-relation between the output of the river and the filtered water pumps becomes quite a serious matter, and a lot of consideration was given to this question when the plant was designed. In order to reduce the inter-adjustment of these pumps and the subsequent power wastage to a minimum it was decided to obtain the necessary speed variation in order to meet varying demands for water by adjusting the periodicity of the generators between the limits of 45 and 55 cycles per second. This again made it necessary that the characteristics of the respective pumps should, as far as possible, be identical with the common speed variation, and the question of dealing with the unavoidable differences mentioned was overcome by the introduction of an individual speed control for each motor. Tests of the combined control extending over several days were made, and they proved that within the periodicity limits previously mentioned the final output of both units can be controlled by varying the speed of the turbo-alternators without re-adjustment of the motors or pumps in any way.

There are at present two sets of turbo-centrifugal pumps in the engine-room, each driven by a steam turbine through helical gear. The whole of the plant was constructed by W. H. Allen, Sons and Co., Limited, of Bedford, England. The pumps are of the multi-stage centrifugal type, consisting of four stages in series. The suction branch is 18in. and the discharge branch is 16in. in diameter. Both the suction and delivery branches are at the bottom of the pumps. The casing is of cast iron and the impeller and guide vanes are of bronze. The shaft is of steel furnished with bronze sleeves where it passes through the water spaces and through the glands. The casings were tested to a pressure of 440 lb. per square inch, *i.e.*, double the normal working pressure. The impeller shaft is carried in two bearings entirely outside the pump casing and is carried to a low-speed gear shaft through a pin type of flexible coupling. The complete set—that is, turbine, gearing, and pump—are fitted on one common bed-plate. The pumps are normally primed from the delivery main, but alternatively it can be done by means of air pumps belonging to the condensing plant. An auxiliary steam-driven reciprocating oil pump is fitted to each set. The steam supply is automatically controlled by the main oil pressure. Should it fail for any reason, an auxiliary oil pump is brought into action and it maintains the oil supply. The auxiliary pump is also used when starting and stopping the main set. The governor gear is fitted with a hand speed control which gives a comparatively large speed range—plus or minus 15 per cent.—to enable the set to operate at the most efficient speed to suit pumping conditions. In addition, an emergency trip governor is fitted to shut off the steam supply to the turbine should the speed reach 5500 revolutions per minute. The high speed gear shaft is carried in three bearings, one of which is interposed between each helical wheel. The low-speed gear is carried in two bearings.

A Floating Water-wheel.

At Prieska, in the Cape Province, a scheme to irrigate part of the local municipal commonage by means of a floating water-wheel, invented by Mr. Mader van Niekerk of that town, has recently been completed. The water is pumped a distance of 280ft. and a height of 40ft. from the source. The wheel has eight V-shaped paddles just over 13ft. long and nearly 14in. wide, and a diameter in the centre about 6ft. 4in. It is mounted on an airtight tank, so that it floats and can rise and fall with the level of the river through any height up to 36ft. without human attention. The pump, with the necessary gears, is arranged on the river bank, and the wheel and tank are connected to it by a shaft having universal couplings at each end. The length of stroke of the pump can be regulated from about 2½in. to 10in., and there are two cylinders each of about 6in. in diameter, and it is stated that 25 strokes to the minute can be obtained with the water flowing at a speed of three miles per hour.

Electrification of the South African Railways.

The contract for the electrical equipment for the Cape Town suburban railway lines has been secured by the English Electric Company, Limited, of Queen's House, Kingsway, London. The contract, which runs into between £300,000 and £400,000, was secured in the face of strenuous competition from continental firms. Further details are now available regarding the contract for the generating plant required in connection with this scheme. The orders, which were placed by the Electricity Supply Commission of South Africa, were secured by James Howden and Co., Limited, and the Mirrlees, Watson Company, Limited, both of Glasgow. There are to be three units, each of which will consist of a 10,000 kilowatt turbo-alternator, complete with surface condensing plant. The turbines will be of Messrs. Howden's latest design, and will be coupled direct to English Electric alternators, designed to develop 10,000 kilowatts when running at 3000 revolutions per minute. The alternators are 12,000-volt three-phase 50-cycle machines. All the condensing plant, with its auxiliary pumps, will be supplied by the Mirrlees, Watson Company, Limited, under a separate contract. The condensers will each be rated for a duty of 104,000 lb. of steam per hour, with a vacuum of 29in. and cooling water at 55 deg. Fah. The surface area of each condenser is to be 16,600 square feet. Air pumps of Mirrlees steam ejector type will be fitted, each unit having two ejectors, one of one-third and one of two-thirds the total air capacity required. Condensate pumps of the firm's patented design for high lifts will be used, and the circulating pump equipment will comprise 27in. and 16in. Mirrlees vertical spindle centrifugal pumps. The contract for the boiler plant has been given to Babcock and Wilcox, Limited.

Transvaal Record Gold Output.

The Transvaal total gold output for 1924 was 9,597,734 fine ounces, which is well ahead of the previous best record of 9,296,618 oz. made in 1916. The value of the gold produced is returned at £43,038,905, but that is after deducting exchange and realisation charges. Without this deduction the value would be over 44½ millions. At even the lower figure the amount is still a record. The total mineral production of the Union for the year 1924 is not yet available, but will certainly not be less than 58 millions being yet another record and by a substantial amount.

Anti-friction Bearing Applications for Heavy Duty.*

By J. B. DAHLERUS, of Luton, Associate Member.

DEVELOPMENT OF ANTI-FRICTION BEARINGS FOR HEAVY DUTY.

SINCE the fundamentals of ball bearing design were given a sound mathematical basis by Professor Stribeck in 1900, much has been said and written regarding anti-friction bearings. Innumerable types of bearings were produced, not only of those in which balls were the rolling elements, but also where rollers were employed. Many wonderful things were claimed for some of these bearings with regard to ability to deal with heavy duty, and also as to their frictionless qualities. However, the acid test of experience very quickly indicated that some types would have to retire from the field of competition entirely. The missing quality was always that of durability. Designers seemed to be interested chiefly in obtaining large contact areas, and in their efforts along these lines unfortunately neglected many other essentials.

Eventually it was realised that it was not sufficient to state simply that a bearing dealt with so many pounds load at a certain speed. This statement required qualification, in that its fatigue-resisting properties would have to be defined, as well as its load-carrying capacity. This aspect of the subject could only be developed by reference to the most extensive range of experiments and to available data regarding bearings which had been operating under practical conditions. This method of treatment has already yielded information of a most helpful kind.

Practical experience indicated that ball bearings could certainly deal with heavy loads at comparatively high speeds, but such bearings would have to be of dimensions which were quite impracticable in many cases, so that the practical side of the problem resolved itself into producing a bearing which would be able to deal with approximately twice the amount of load that a ball bearing of the same dimensions would take. Such a bearing should also have the following characteristics:—(*a*) Minimum friction; (*b*) capable of dealing with both radial and thrust loads; (*c*) ability to deal with thrust load in either direction; (*d*) the unit should be self-contained, have no loose parts, and should be non-adjustable; (*e*) should be capable of quick inspection; (*f*) should have the feature of self-alignment.

These demands are of a very stringent nature, and it was only after most exhaustive research that a bearing capable of meeting each and all of these conditions was produced. A section of the bearing illustrating the main features is shown in Fig. 1. These features are as follows:—(1) The raceway in the outer ring is spherical. (2) The rollers are barrel-shaped, and the greatest diameter is not at the centre of the roller, but is offset towards the centre of the bearing. (3) The inner ring has two grooves for the rollers, having exactly the same radius of curvature as that of the roller. (4) The end of the roller towards the centre of the bearing is ground spherically, as is also the flange on the inner ring against which the roller end bears. Since the surfaces in contact are spherical, there is a definite area of contact, which extends on each side of the plane A B indicated by the light hatched lines. (5) The fact that the large diameter of the rollers is offset towards the centre of the bearing means that a certain small proportion of the radial load on the bearing keeps the roller in continuous contact with its mating flange. Consequently, should there be the slightest tendency for the roller axis to get out of parallelism with the axis of the bearing, this tendency is immediately corrected by the width of the contacting areas. (6) The curvature of the rollers is slightly greater (that is, the radius is smaller) than the spherical race track in the outer ring. (7) The lines through the neutral points in the roller contour which converge to the apex *a* on the axis of the bearing are virtual tangents to the roller surfaces, and consequently conform practically, if not absolutely, to the theory of pure rolling motion.

The double-row roller bearing thus described has actually twice the capacity of a ball bearing of similar dimensions, and provides the necessary flexibility, which will compensate for slight errors in manufacture of housings. The bearing, however, does not provide for lateral flexibility, and to obtain this the well-known type of cylindrical roller bearing has been adopted. The usual parallel outer race, however, is such that it does not permit of any self-alignment, and only adapts itself to lateral displacement. The consequence of this was the modification shown on Fig. 2. The chief feature here is that the raceway in the outer ring is not cylindrical, but convex. The convexity is not great, and is just sufficient to permit of a very slight amount of misalignment taking place, without interfering with the correct functioning of the bearing.

Having thus briefly referred to the development of these heavy duty bearings, it is only necessary now to refer to some of the more obvious matters which concern the users of such bearings. These are:—

Saving in Power.—This, of course, depends on a comparison between the plain bearings normally employed and the roller bearings, and obviously the lower the coefficient of friction of the latter, the greater will be the power saving achieved.

Increased Production.—That an increase in production may be possible by fitting such bearings is not always obvious, but it is a fact that tests in some instances do prove that this is so.

Improvement in Quality of Production.—It has also been demonstrated in a practical manner that the quality of the material passing through the machines is improved in some instances.

Reduction of Maintenance Charges.—The fact that less oil is used with anti-friction bearings, and that hot bearings are less likely to occur, will in some classes of work effect considerable reduction in maintenance charges. Oiling takes place only at infrequent intervals, and the amount of lubricant may be only one-tenth of that required with the ordinary bearing.

Acceleration, &c.—No matter what type of machine is being considered, the fact that anti-driction bearings have a starting resistance practically the same as the running resistance means that the reserve of power often required for starting becomes unnecessary, and machines may be speeded up to their normal rate of working in relatively short periods.

RAILWAY WORK.

Midland Railway Tests.—The results obtained by the Midland Railway Company in testing out its standard plain-bearing journals against roller-bearing axle-boxes, as shown in Fig. 3, form a useful basis for discussion.

An examination of the white metal bearings taken from Midland Railway coaching stock after 100,000 to 150,000 miles' running showed that these had a mirror-like surface. The bearing is relieved at the sides during erection, so that the actual bearing area is not definitely determinable, but through time the journal beds itself in at the most comfortable position. It should be explained that the workmanship and maintenance of these plain bearings on the Midland stock is of the highest quality, the journals being truly round with perfect finish, and only the finest material used in the brasses and lubricant. It is estimated by the Midland Railway Company that probably at least one month's running is necessary to bed in the journal on the white metal. During this period the friction coefficient is probably in the region of 0.007 to 0.01. In cold weather or on short-distance work these values would still be maintained, but on long-distance express traffic, where the bearing has an opportunity to achieve a state of permanency, the coefficient may commence at 0.01 but drop ultimately to 0.002.

Particulars of Trains Tested.—Set train No. 232, consisting of thirteen four-wheel bogie passenger stock vehicles, total weight empty 312 tons, total length over buffers 649ft. This train was fitted with roller bearings for the axle-box journals, on the coaches only.

Set train No. 233 was identical with the above, with the exception that Midland standard plain bearings were fitted on the axle-box journals.

Tests.—On Sunday, April 15th, 1923, the two trains were worked from Kentish Town to Leicester and back under similar conditions, the coal consumption being taken and the work done on the trains being recorded by the dynamometer car, which was coupled up between the engine and train being tested. The complete trip between Kentish Town and Leicester and return is 195 miles. The same class of coal was used throughout the tests.

TABLE I.—*Comparison of Coal Consumption—Sunday, April 15th, 1923.*

Kentish Town to Leicester and return.

	Plain-bearing train.	Roller-bearing train.
Train, car and engine, tons	444.6	444.6
Mileage (Kentish Town to Leicester and return)	195.0	195.0
Coal used, lb.	5898	6387
Coal per ton-mile, lb.	0.06803	0.07367
Coal per mile, lb.	30.2	32.8

Compound engine No. 1034 worked both trains, the timings were as near as possible identical, and the weather conditions remained practically constant throughout the day, except for the last part of the return trip with plain bearings, when it rained slightly for about one hour. It was necessary, however, for different sets of men to work the two trains. The results obtained are shown in Tables I. and II.

TABLE II.—*Comparison of Resistances of Plain and Roller-bearing Trains.*

Kentish Town to Leicester and return.

	Plain-bearing train.	Roller-bearing train.
1. Weight of train, excluding engine and dynamometer car, tons	312	312
2. Total distance run, as recorded by dynamometer car, miles	195.10	195.23
3. Net work done in working the train, as measured by by the integrator, ft.-lb.	3,285,174,750	4,484,280,250†
4. Total running time, hours	4.417	4.449
5. Average speed, m.p.h.	44.17	43.88
6. Average draw-bar pull at rear end of dynamometer car, tons	1.424	1.510
7. Average resistance in lb. per ton (train only)	10.223	10.841
8. Increase in case of roller bearings, as compared with plain bearings	—	6.04

It will be noted that, although the average speed of the roller-bearing train was slightly less than that of the plain-bearing train, the coal consumption was 8.28 per cent. more and the net work done, as recorded by the dynamometer car, 6.04 per cent. greater.

Train resistances were deduced from the dynamometer records whenever it was possible to ensure that the whole of the train was on the same gradient. It was found that, while at the beginning of the outward run the roller-bearing train indicated a lower resistance than the plain-bearing train, after some distance had been covered conditions were reversed, the plain-bearing train showing the lower resistance. Thus, although starting at a disadvantage as compared with the roller-bearing, the plain-bearing gradually improved until it became more efficient than the roller-bearing, and therefore on a run of any length the total work done, as measured by the integrator, is less for the plain-bearing train.

On Sunday, April 22nd, 1923, coasting tests were made between Westcliff and Benfleet, with each of the above trains under similar conditions, the first portion of the run being on a down grade of 1 in 94, full particulars being recorded by the dynamometer car. The dynamometer car was fitted to the rear of each train in order to obtain an accurate record of the speed. The reaction between the train and the car was also recorded, so that it was possible to obtain values for the resistance of each train by eliminating the effect of the dynamometer car. Each train at the commencement of the test was propelled into position and brought to rest at the same spot at the top of the bank at Westcliff. The engine was then uncoupled and the train allowed to start under gravity, thus ensuring identical conditions. The results of these tests are shown graphically in Figs. 4, 5 and 6.

Fig. 5 gives the speed for the two trains at the same points on the bank, plotted on a distance basis. Resistances are also shown for the two trains, these values being calculated from the acceleration derived from the time pen on the dynamometer record. The rotary inertia of the wheels of the trains has also been included in the calculations, being an average of 8 per cent. of the net weight of the train. In order to facilitate a comparison of these resist-

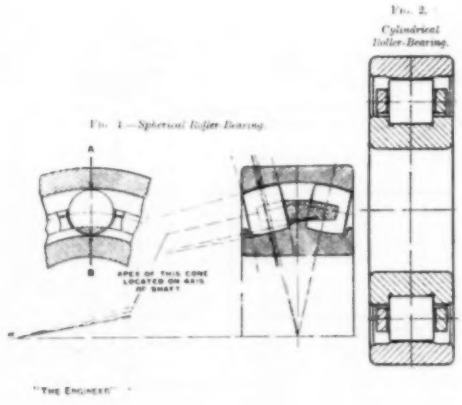


FIG. 1.—*Spherical Roller Bearing.*

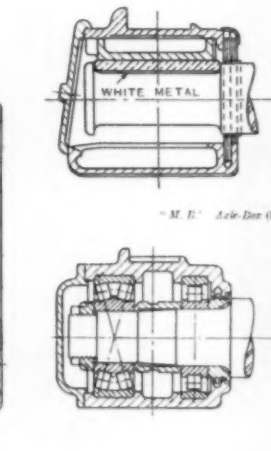


FIG. 2. *Cylindrical Roller-Bearing.*

FIG. 3.—"M. R." *Standard Axle-Box (Plain-Bearing).*

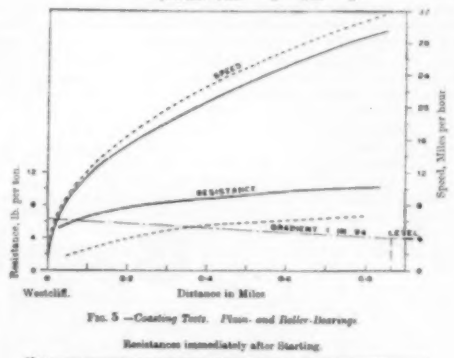


FIG. 4.—*Coasting Tests. Plain- and Roller-Bearings.*
Westcliff-Benfleet. Sunday, 22nd April 1923.
Set Train { No. 232. Roller-Bearings, Dotted lines. No. 233. Plain " Full "

FIG. 5.—*Coasting Tests. Plain- and Roller-Bearings.*

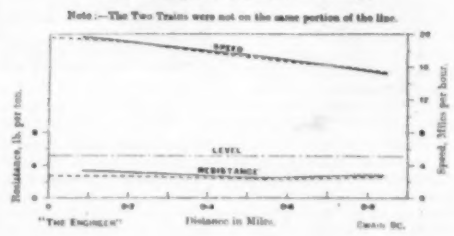


FIG. 6.—*Coasting Tests. Plain- and Roller-Bearings.*

* Institution of Mechanical Engineers.—Abstract.

† Query 3,484,280,250.—ED. THE E.

ances at similar speeds the results have been plotted on a speed basis, as shown in Fig. 5.

In Fig. 6 the speeds of the two trains are plotted when running on the level and the track straight, portions of each trip being chosen for comparison at which the speeds of the train were approximately the same.

In comparing Figs. 4 and 6 it will be noted that in Fig. 4, which shows the first portion of the coasting test down the bank, the acceleration with the roller-bearing train is appreciably greater compared with that for the plain-bearing train, and the maximum speed recorded with the roller-bearing train was 32 miles per hour at the bottom of the bank. With the plain-bearing train the maximum speed was about 29 miles per hour at about the same point. Again, the resistances for the roller-bearing train, as shown in Fig. 4, are considerably less than those for the plain-bearing train at similar speeds. In Fig. 6, representing the conditions when the trains were running on the level at similar speeds towards the end of the run, it will be noted that the difference in the resistances for the two trains is practically negligible. The roller-bearing train is still in service to determine endurance, and periodical examinations are made to ascertain the condition of the boxes. So far the examination has revealed that the bearings are standing up to their work without the slightest sign of stress.

Great Northern Railway.—A two-bogie passenger coach was fitted with eight roller-bearing axle-boxes on October 30th, 1922, the load per box being 4 tons. On September 21st, 1924, the mileage covered by this coach was 141,476. Periodical inspections are also made here, these indicating that the bearings are standing up very satisfactorily.

American Rolling Stock.—Some time ago trials were commenced on the Pennsylvania Railroad, in which one double-row self-aligning roller bearing was used per axle-box. The bearings were mounted on passenger bogie coaches used on express traffic between New York and Pittsburg and between Philadelphia and Pittsburg. There are five four-axle coaches, each weighing 60 tons, and one six-axle combined passenger and luggage wagon weighing 80 tons, and these are all in service. Some of these coaches have been in service since 1921. With the temperature of the atmosphere about 50 deg. Fah. the temperature record of the roller bearings in service indicated a maximum of about 85 deg. to 95 deg. Fah. Plain bearings used in the same train became heated to a temperature of about 175 deg. Fah. A considerable decrease in starting friction has been obtained, and the saving of coal indicated is about 14 per cent., and the saving of lubricant about 90 per cent. The tests were intended chiefly as durability tests.

Continental Practice: State Railways in Finland.—On the State Railways in Finland fifty-six axle-boxes were fitted during June and July, 1923, each box having one spherical roller bearing and one cylindrical roller bearing. Forty-eight of these boxes were mounted in six bogie carriages weighing 34 tons to 36 tons each, and eight boxes in two two-axle luggage vans weighing 10 tons. These carriages and a dining car on plain bearings weighing 40 tons have been kept together in a train running between Helsingfors and Abo. During the period of September 1st to October 21st the drivers of the respective locomotives kept records of the quantity of coal loaded on the tender after each trip. The results showed for the roller-bearing axles a coal consumption of 854 lb. per 1000 axle miles, representing a saving per 1000 axle miles of 10.3 per cent. as compared with a similar train fitted throughout with plain bearings. Special trial runs were arranged between October 28th and 31st inclusive. The plain-bearing train was found to consume on an average 102 lb. per 1000 ton-miles and the roller-bearing axles 90 lb. After correction for the four plain-bearing axles in the roller-bearing train, the saving works out at 11.5 per cent. It was also found that for the roller-bearing train the acceleration was much greater than for the plain-bearing train in spite of an earlier cut off in the cylinders. At one point on the line it was necessary to apply steam on the plain-bearing train, whereas the roller-bearing train ran with the steam shut off. Other measurements were taken on tests between Helsingfors and Kyrkslätt and a saving of 10 per cent. was obtained. On a test between Abo and Salo a saving of 15 per cent. was recorded.

It has to be admitted that the different methods of measuring were somewhat approximate, but as the agreement in the results with the different methods is fairly close, the final values may be considered comparatively reliable, and an average coal saving of 10 per cent. may consequently be considered as definite for the conditions of these tests.

Swedish State Railways.—On the Swedish State Railways 1366 axle-boxes have been fitted. Each box has one spherical roller bearing and one cylindrical roller bearing, the load on each axle-box being 5½ tons. Tests were carried out for economy, and although full details are not available for publication, it may be stated that the Swedish State Railway engineers found that the fuel saving was between 13 per cent. and 14 per cent. It was after these preliminary tests that the large number of boxes mentioned above was installed.

An average figure for the cost of these roller-bearing boxes is about £20 each, complete with bearings and fittings, but, of course, this varies with the size of the box and with the quantities which are required of any given design. This figure as to cost has been inserted to give the engineer some idea on which to base preliminary estimates if he is so interested.

Finally, there are other applications in railway work which have had attention, but have not exactly the same interest as the axle-boxes. Such applications include the return crank of Walschaerts gear—an application originally developed by Mr. Gresley of the G.N.R., in 1916—train lighting sets, and, to a small extent so far, signalling apparatus.

Tramway Work.

With the development of the heavier types of roller bearings described interest centred round applications to tramways.

Motors.—In America, the Continent, and this country great attention has been paid to tramway motors, and it was natural that in the development of anti-friction bearings for these units the ball bearing was the first to be tried. A fair amount of success was achieved in America and on the Continent, but in this country tramway engineers had a preference for the roller type bearing, and certainly this preference is justified in a great number of cases, although it must not be overlooked that ball bearings have given satisfactory performance.

The arrangement referred to in this paper has the great advantage of being a simple two-bearing unit and the only complication which arises is in the method of providing suitable protection, particularly at the pinion end. A design which has found favour and has been proved thoroughly practical is shown in Fig. 7. It would be difficult to determine exactly what economy in power saving could be obtained from this application, but the advantages of being able to keep the armature centred accurately in the magnetic field and also preventing the disastrous results due to the armature dropping and fouling the pole pieces are more or less self-evident. Many hundreds of motors have now been so equipped.

Axle-boxes.—Tramway axle-boxes, in common with railway axle-boxes, have had their share of attention as regards roller-bearing design, and two typical arrangements have been developed. As is well known, the axles have to be removed fairly frequently for the purpose of re-tiring the wheels, and the nature of this operation is such that it is necessary to remove the bearing boxes. To facilitate the removal of the boxes designs have been tried with special sleeve mounting fitting on the taper end of the axle. This, however, necessitated comparatively large bearing boxes, and as the outside dimensions of the box were restricted, it meant using comparatively light types of bearings. Such a design has not proved satisfactory, the chief trouble developing being due to the locking arrangement for the sleeve being somewhat unsound in design, and it is indeed difficult to arrange for a sound locking scheme on account of restrictions regarding the overall dimensions over the boxes. Eventually the design shown in Fig. 8 was developed, which permits of a sound method of mounting and the use of medium type bearings. This design is being tested at present, and so far it would appear that it has overcome the chief difficulties.

Economy in power is probably the most important feature here, and to determine to some extent what might be expected, two different bearing manufacturers have had very complete and exhaustive tests carried out for them by the National Physical Laboratory.

Glasgow Tests.—This test was conducted by the National Physical Laboratory in May, 1923, a comparison being made between a car fitted with one double-row spherical roller bearing and one cylindrical roller bearing per axle-box, and also on the motors against a car fitted throughout on plain bearings. The axle-boxes were of the Brill type and had the sleeve mounting for the bearings previously referred to. Tests were made in the first place on the car as ordinarily fitted with plain bearings, and secondly, on the car after conversion to roller bearings of the types described. The percentage saving of electrical energy in favour of the roller-bearing car was definitely determined as 11.62 per cent. on the average, the minimum being 0.6 per cent. for one small section of the run, and a maximum of 17.5 per cent. on another section.

The tractive resistance at half load and at an average speed of 8 miles per hour showed a reduction of 22.6 per cent. in favour of the roller-bearing car, 29.6 per cent. when unladen, and 14.9 per cent. on full load. At 16 miles per hour the reduction at half load was 8.4 per cent., unladen 8.9 per cent., and on full load 8.4 per cent.

The starting effort for various loads indicated an average reduction of 79 per cent. Coasting tests were made on an up gradient of 1 in 730, and although the track was not sufficiently good for the test owing to the gradient not being uniform, the following approximate results were obtained:—Retardation of plain-bearing car = 0.49ft. per second per second; retardation of roller-bearing car = 0.32ft. per second per second.

Rolling Mills.

It will be admitted that the loads on rolling mill bearings are perhaps the most severe to be found in the whole field of engineering, particularly considering the speed and the nature of the material which is being handled. The average pressure intensity with which plain bearings have to deal may be in the region of 1½ to 2 tons per square inch. It cannot be overlooked that the difficulties in connection with this particular application are very great, and while for certain classes of work satisfactory bearings are available, there still remains the question of the roll trunnions and housings.

Conversions.—If an existing mill has to be modified the chief difficulties to be faced are:—(1) To obtain sufficient room in the housings for the bearing, without leaving the material of the bearing housings too thin. (2) Since the outside diameter of the bearing is restricted, a heavy type of bearing with a relatively small bore must be employed, and consequent upon this the roll trunnion must be reduced. (3) When the roll trunnion is reduced its strength can only be brought back to normal by the use of special steel shafts, either cast or shrunk into the roll. (4) The facilities for removing the roll from the frame must present no difficulties to the workman attending to this duty, and at the same time the bearings should be removed complete within their housings in order to ensure that there will be no unnecessary handling of the bearings themselves, with the consequent danger of intrusion of foreign matter, metal particles, &c. For a number of different types of mills, already fitted and in operation, the various problems outlined above have been satisfactorily solved. Wire and rod mills have been found to present less difficulty than sheet mills, but the extension of the principle appears to be chiefly a matter of time and progressive development.

In some experiments carried out on sheet rolling mills by W. H. A. Robertson and Co., Limited, in collaboration with the Skefko Ball Bearing Company, Limited, Luton, two mills with 8in. diameter rolls were tested, one fitted with spherical roller bearings and one fitted with ordinary bearings. The speed of the rolls was 48 revolutions per minute, and the rolling speed 84ft. per minute. The metal rolled was common brass strip, annealed, the width of strip being 5⅝in. to 5¾in. The thickness before rolling was about 0.03in., and the reduction per pass was on an average 0.01in. In the roll fitted with the roller bearings a quantity of about 5 cwt. was put through during a test period of about one hour. The same quantity of material was rolled in about the same time in the mill on ordinary bearings. A comparison of the power taken in both cases showed a saving of 31.7 per cent. under actual working conditions in favour of the roller bearings. During some parts of the test a saving of 50 per cent. was indicated. It is also to be noted that with the ordinary bearings the power increased from the beginning to the end of the trial due to heating of the bearings, so that if the trial had been continued for a longer period the average power consumption would have been increased, while with the roller bearings no increase with time occurred. Further trials have indicated an average saving of 43.5 per cent.

FIG. 7.—*Tram Motor.*

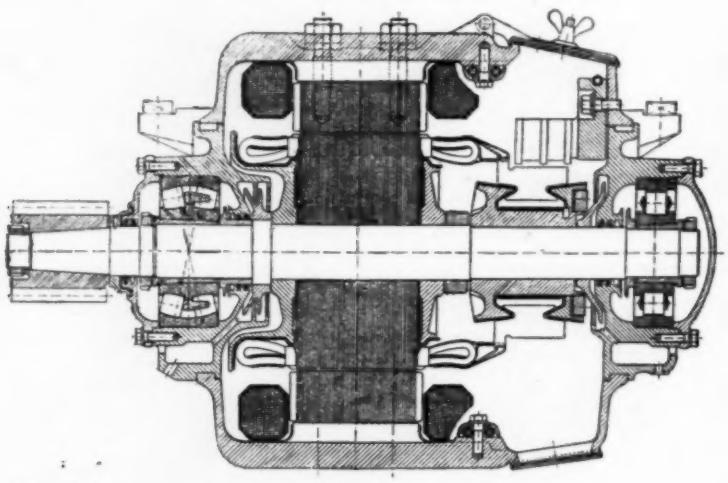
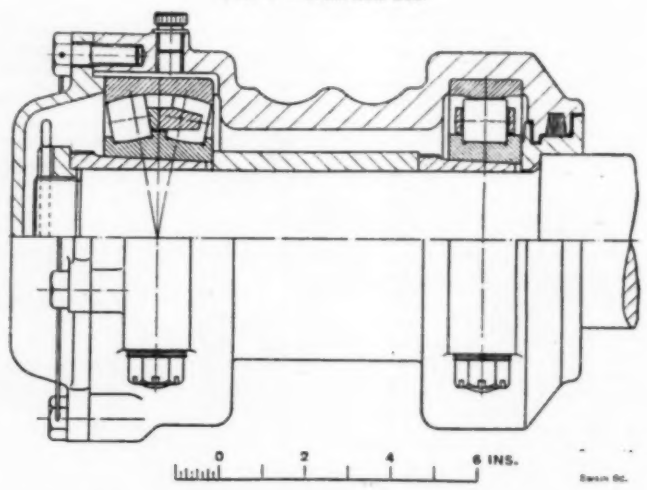


FIG. 8.—*Tram Axle-Box.*



ONE mistake that is often encountered in the operation of oil-fired boilers is the practice of attempting to maintain too high a temperature of the fuel oil. The best results are obtained when the oil is at a temperature just sufficient to ensure proper and complete atomisation. If too hot, the oil tends to turn into vapour and the burners puff and feed irregularly.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Market Position.

THOUGH iron and steel makers in the Midlands continue to look for an improved demand they are getting but meagre business at the moment. On 'Change in Birmingham to-day—Thursday—demand was severely restricted, and was in no way commensurate with current production. Material can hardly be turned out at a profit in many branches, and not a few manufacturers are known to be trading at a loss, but consumers continue to press for lower prices. Some of the bids to-day were so much below the late level of the market as to suggest that they were purely speculative. Producers, with some exceptions, put up a stubborn resistance to the deterioration. They take the view that no readjustments which are compatible with present production costs would broaden the market. A few pig iron orders were taken on rockbottom terms, and in several cases steel masters shaded quotations for constructional material.

Steel.

Demand for steel remains fairly good, though tonnages are small. The business in hand is chiefly for structural needs, including a good deal of pipelaying steel for municipalities, but it is very unevenly distributed. Though heavy engineering is not getting any new estimates, some of the steel mills are fairly well off for orders. Under the pressure of keen competition prices have weakened a little and a figure as low as £8 15s. is said to have been accepted for joists and sections. The official basis of £9 5s. is merely nominal. Competition for an inadequate amount of business is rife in the tube trade. Heavy strip prices are severely cut on big scale orders. Plates are in no better inquiry. Foreign competition at the moment is less severe, in the sense that material is not being pressed on the market. But foreign prices are still low, Belgian finished bars being obtainable at £6 f.o.b. Antwerp, or about £7 2s. 6d. delivered here. This price compares with the home quotation of £9. Birmingham merchants naturally take advantage very largely of this cheap steel for the execution of foreign orders shipped direct from Belgium. Local makers of bedstead angles are stabilised for the time being at £9 15s. Welsh interests, which were offering soft billets at £7 a week ago, quoted £7 5s. yesterday, having sold their output for some time ahead. Continental billets could be bought at £6 5s.

Pig Iron.

The pig iron position is much the same as it was a week ago. The present market stagnation tells less in the pig iron department than would otherwise be the case, because a considerable proportion of the make has been already sold. There is, moreover, heavy pressure in the pipe trade. Midland smelters who are under pressure to sell continue to meet buyers to some extent in the matter of price. They still hope, however, for a reinvigoration of the market, and prefer to regard concessions as emergency measures. Midland blast-furnaces are just able to dispose of their output. Forge iron sells very slowly, in view of the very dull state of the Staffordshire iron trade. Weakness of coke is the important element in the raw iron situation. Supplies are plentiful. The recent effort to force up prices has proved a failure, and it is believed in some quarters that a definite reduction in the standard of 16s. 9d. is to be looked for. In the pig iron department the very low exports are the most serious feature. The January shipments to foreign ports from Middlesbrough totalled 13,227 tons, representing a steady reduction since October, when the total was 28,334 tons. It is admitted on all hands that iron-making is unprofitable at present prices, but it is impossible to maintain a firm market.

Staffordshire Bar Iron.

Activity in the Staffordshire finished iron department is restricted almost wholly to marked bars, for which the price is maintained at £15. Good quantities are being called for for engineering work and other special requirements. The Staffordshire mills concentrate more largely on re-rolled steel, but the capacity far exceeds the demand, and in this department some falling off in the tube trade has reduced the business both in iron and steel strip. A number of the ironworks are, however, able to make partial production, with the aid of this re-rolling steel business, but foreign billets are largely used. Foundries are rather busier, owing to the improvement in the machine tool trade, but the chain and anchor trades continue dull on account of the poor demand for shipbuilding. The nut and bolt works are slightly busier in connection with bridge building and other schemes, but there is little demand for Staffordshire nut and bolt iron at £11 15s. Manufacturers are using, to an increased extent, No. 3 Belgian iron, obtainable delivered at £7 15s. Staffordshire iron masters cannot hope to get business against this figure. The nut and bolt trade is using slightly more material, but there are still heavy stocks of unused bars on hand. Ironmasters on 'Change in Birmingham to-day discussed the proposals of the Government for safe-guarding hard-hit industries against unfair competition. Estimates of the value of the proposals were very varied, but all appear to be agreed that the British iron trade is in a grave position and has never stood more urgently in need of help.

Galvanised Sheets.

Galvanised sheet prices continue slightly weaker, £17 2s. 6d. to £17 5s. being the figures generally ruling for corrugated sheets of 24-gauge. The works are fairly engaged. The demand of Birmingham merchants and various hardware trades shows a little expansion, and the cycle and motor industries are useful customers for thin sheets. Black sheets are in good demand and values are firm.

Birmingham to the Sea.

From time to time a live interest has been roused amongst Midland industrialists in the question of linking up Birmingham and the Black Country generally with the sea by a more direct canal route capable of carrying heavier barges. Several schemes have been put forward and investigated during recent years by a special committee appointed by the Birmingham County Council and recently reports have leaned towards the route to Bristol and the Severn. Now the committee has decided to investigate further possibilities of the route through the Potteries to the Mersey—a route dismissed a year ago as impracticable—and meanwhile to postpone further consideration of the Severn Waterway improvement scheme. The prime factor in this change seems to be an engineers' report. The two engineers concerned are the city surveyor—Mr. H. H. Humphries—and Colonel Saner, engineer to the Weaver Navigation. The greatest recommendations of the new scheme are its comparative shortness of 82 miles, its freedom from more than 24 lifts or locks, and the estimated length of time between Birmingham and the Ship Canal of 34.6 hours, against the time of 50.2 hours for the journey between the two extreme points at the present time. The total volume of traffic that could be handled is computed at 6,720,000 tons in a year of 280 working days. The new scheme is undoubtedly worthy of careful consideration, but before any decision is made by the local authorities concerned it will have to be proved that canal transport is genuinely required by manufacturers in the Midlands, and that it can compete successfully with the railways and the roads.

Workless.

The latest unemployment statistics for the Midlands area show a further substantial decline in the number of workless, 4634 having been absorbed into industry since the previous return a week ago. The latest figures give a total of 146,329, as compared with a total for the previous week of 150,963, and for the week ended January 12th of 154,647, so that in the past three weeks there has been a decrease of 8318 in the number of unemployed registered. Of the total 99,448 are men, 2718 boys, 40,205 women, and 3958 girls.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

General Outlook.

THE general condition of the iron and steel markets is very far from satisfactory this week. The amount of business coming to this centre seems to be rather less than might have been expected from the reports of orders given out by railway companies, and Lancashire is certainly of opinion that it has not got a fair share of this work. However this may be, there is at present little prospect of improvement for the next month or two, and prices seem very much inclined to sag. One cannot see that any downward movement can go very far in existing circumstances, because there is little or no profit at the present market rates; but it is fairly clear that consumers of iron and steel have satisfied themselves that there is no risk in remaining uncovered up to the moment of actually wanting the material to go on with; and this conviction, of course, tends to keep the markets dull.

Metals.

The very sharp setback in all the leading metals has certainly done a good deal to strengthen the position in the non-ferrous metal market. Weak holders of metal have been shaken out, and the situation is now less open to attack by "bear" sellers. One would not be surprised to see the whole of the loss in values regained, and perhaps some little increase added to it, more especially in the case of copper and tin, for with regard to those metals there was really nothing in the nature of things to justify the setback. It is, of course, true that the production of copper is large, and that a large consumption will be needed to keep the prices steady; but so far as can be seen, the consumption of copper this year is going to be large. There are very important outlets for copper so long as it remains one of the cheaper metals, and it cannot be denied that refined copper at about £70 per ton is very cheap in comparison with most other leading products. It is at fairly moderate pre-war prices, whereas almost everything else is from 50 to 100 per cent. above the moderate pre-war prices. There are a good many electrical projects about now in various countries, which will mean a large increase in the demand for copper, probably during the current year, and one cannot see that present prices are in any danger. The market for tin has recovered to a certain extent, and the statistics for this metal certainly show up well; but the market is at present more under the influence of imagination than of hard facts. At the moment, America seems to have a fair stock of tin on hand, and may not be a large buyer for perhaps a month; but if the tin-plate trade continues to improve, there is every reason to believe that buying on a large scale will soon set in. Here the general belief is that tin will be a good market during the spring months; but, of course, speculation in tin is not a prominent feature of the Manchester market. Lead had a severe fall, but is recovering very fast. Apparently, the time has not yet come for cheap lead. Spelter is also recovering from the slump, but in this case the fall seems to have been mainly of a sympathetic character. The general outlook in spelter does not seem to be unfavourable.

Pig Iron.

The demand here for pig iron is feeble and intermittent. There would seem to be no large transactions, or if any, they are very occasional, and it is doubtful whether the volume of small business is being maintained. The idea of consumers that by waiting till the last moment their chances of getting easier prices are improved, seems to be spreading steadily in this district, and the only occurrence likely to check it would be a sharp advance in the Cleveland market. This is improbable so long as the export trade in Cleveland iron remains in its present comatose condition. It has to be admitted now, even by sellers, that the position of Derbyshire foundry iron is weak. Probably some exaggerated rumours of low prices are afloat, but their very existence is an indication of weakness in the market. There are still one or two sellers in Derbyshire No. 3 who try to keep to 90s. per ton in Manchester, but considerably less would now be accepted for substantial orders, and especially for orders over the next two months. This is perhaps a proof that makers of Midland pig iron are no longer expecting any revival before Easter, and are desirous of securing work for the furnaces. Probably 88s. 6d. delivered in Manchester may now be considered a regular price for Derbyshire No. 3. As for forge pig iron, the demand is very slow, and the nominal prices in the Lancashire district are from 83s. to 84s. per ton. Further weakness in the Scottish iron market is reported, but the price delivered here does not fall below 105s. No improvement is yet to be seen in the condition of the ironfoundry trade in Lancashire. Some textile engineers are fairly busy, but the general demand for new cotton machinery has not yet set in. No doubt spare capital is wanted for buying machinery, and recently the cotton trade has become less profitable.

Steel.

Merchants engaged in the finished steel trade here do not appear to be more cheerful, and new business remains very scarce. There had been some inquiry, but the competition is exceedingly keen, and it is clear that prices are cut. The nominal quotations for finished steel remain as they were, viz., £9 for joists and angles, £9 15s. for plates and flat bars, and £10 for round bars; but according to report, the last big order for round bars of various small sizes for reinforced concrete work was taken here by a firm of merchants at less than £9 15s. per ton.

Scrap.

There is only a very moderate demand now for scrap of any kind. Dealers in Lancashire usually offer 62s. 6d. to 65s. per ton for heavy steel melting scrap, although it is said that up to 80s. is paid in Sheffield for this scrap when any business is done. The forges are not inclined to buy much wrought scrap now, and probably 85s. delivered would be all that could be obtained for good lots. There is no change, either for the better or the worse, in foundry scrap. The idea of price for good broken machinery iron is 85s., but this seems to be a seller's and not a buyer's idea.

A Brighter Outlook.

At the annual meeting of the members of the Manchester Chamber of Commerce, held on Monday last, Dr. Alfred Rée, in his address, pointed out what he considered were favourable factors in the trade situation at the present time. In the first place, he said that the raw cotton position was immensely improved by the satisfactory crop in America. Then the position was better in several of our leading markets, while, finally, there was a marked improvement in world stability and an encouraging atmosphere of restrained confidence everywhere. In spite of the increase in the cotton exports last year, as compared with those of 1923, Dr. Rée mentioned that there was much leeway to be made up, our exports of cotton goods being still some 2½ thousand million square yards behind the 1913 level, and unemployment in the textile trades was still serious, though not as great as it was a year ago. Referring to the engineering industry of this district, Dr. Rée said the past year had been a difficult one. In times of extreme trade depression, it was not to be expected that orders would be generously placed by the staple industries for new plant and extensions, and unfortunately the custom of placing orders for the renewal and upkeep of plant which would be so welcome to the engineering industry had not prevailed to the usual degree. This was to be deprecated, because keen prices and good service were more likely to obtain at a time of trade depression. The contracts placed by the railway companies had somewhat improved the outlook for the heavy and locomotive engineering branches of the industry, and the constructional section had been less hardly hit than others. In the electrical section the makers of heavy plant had been kept fairly busy, but the manufacturers of industrial equipment continued to feel the general depression. So far as the chemical trade of the district was concerned, Dr. Rée said that the past year compared favourably with its predecessors, both in interest and progress. In some products, such as the heavy soda compounds, our exports had been greater than ever before, while in the home trade the sales of ammonium sulphate for the last half-year were about 40 per cent. in excess of those during the corresponding period of 1923.

A Busy Works in Trafford Park.

In these lean times in the engineering industry, it is particularly pleasant to visit a works where orders are plentiful and where the number of persons employed compares favourably with that in the period immediately preceding the war. There are, alas, very few such establishments in the Manchester area. In fact, I could almost count them on the fingers of one hand. One of them is that of the "Metrovick," as it is familiarly called in Trafford Park. A few days ago I had the good fortune to be shown round this immense factory, which is always full of interest on account of the remarkable variety of products that are made there. In every department of the works orders seemed to be plentiful, particularly in the electrical section and in the comparatively new branch devoted to the manufacture of wireless apparatus. This latter class of work appears to lend itself especially well to female employment, on account of its minuteness and similarity of operations, most of which call for much manual dexterity. I did not inquire how many of the 10,000 hands now employed at the Trafford Park works were engaged in this section, but the number certainly runs into hundreds. Another department which appears to be particularly well off for work is the switchboard

section, in which a large number of very high-tension plants are in course of erection. The developments which have taken place in this branch of electrical engineering in recent years are remarkable, and involve very massive framework, with refinements which are almost bewildering to the casual observer. The transformer section, too, is so busy that it has "overflowed" into other departments of the works. Some very large transformers are at present under construction, and the steam turbine department is well employed. In spite of the vast area which the "Metrovick" works already cover, extensions continue to be made, and in the near future the proprietors propose to construct a new turbine testing chamber, which will be "the last word" in this branch of constructional engineering, and will enable overspeed tests of steam turbines to be carried out with safety and security for those engaged in them.

BARROW-IN-FURNESS.

Hematite.

The condition of the hematite pig iron trade is one of quietness in so far as there has been no development of late for the better. Some time ago, when trade began to improve, it was confidently thought that there would be a steady rise in the demand, but owing to several changes in conditions that rise has not taken place. The present output of iron is practically all being disposed of, but it must be remembered that at Workington and Barrow a considerable amount of iron is going straight to the steel departments, which at the present time are fairly well engaged. The home trade has not broadened out, and the munber of inquiries is not heavy. Plenty of customers are taking just what they require at the moment, although there are others who are placing orders for delivery a month or two ahead. The continental trade is thin, but there are prospects of American business. The charcoal furnace, the only one in this country, is fairly well engaged upon its special product.

Iron Ore.

The ore trade remains about the same, but the future is not so well assured as far as outside deliveries are concerned, as they may fall off, in view of some furnaces going out of blast. The trade locally is about the same. Foreign ore is in steady demand, and imports at West Coast ports are regular.

Steel.

There is nothing fresh to report regarding the steel trade in the district. At present both the Workington and Barrow steel works are engaged, the rail, sleeper and fish-plate departments at the former and the rail and merchant mill at Barrow. Orders are held which will keep them engaged for a short period, but fresh orders are required to guarantee a long run. There are not many orders available at present, and competition is very keen. Hoop and small section mills at Barrow are better off for orders. Foundries are fairly well employed.

SHEFFIELD.

(From our own Correspondent.)

Depression in Iron and Steel.

THE present year has opened badly in many local branches of the iron and steel industry, especially those which produce material of a raw or semi-manufactured character. The hopes of improvement with which the old year ended have not been realised; on the contrary, a further decline has been experienced. During January there was very little resumption of the buying. The Sheffield district is not alone in its depression, for a similar condition prevails generally wherever crude materials are produced. The majority of the blast-furnaces which were stopped at Christmas are still idle, and the demand for pig iron is not sufficient to warrant the lighting up of many of them. The Renishaw Ironworks have, however, been able to bring a new furnace into blast. This furnace, which was finished last November, was put into operation about a fortnight ago, and is now producing pig iron. It is of modern design and has a capacity of about 1000 tons of pig per week. For a considerable time past very few forward contracts have been booked for either pig iron or billets, and only a small number of inquiries are about.

Engineering and Manufactured Steel.

On the manufactured side of the steel industry Sheffield's position is better, but it cannot be called altogether satisfactory, although many thousands of hands are employed. There is a large amount of work on hand in the departments which make axles, tires, springs, and buffers for the railways, and new orders continue to come in. The automobile industry also continues to be a good customer for Sheffield special steels. A few orders for iron and steel works plant have recently been booked by the heavy engineers, and I understand that the contract for a rolling mill for the Crewe works of the London, Midland and Scottish Railway Company has come to Sheffield. Several nice orders have recently been booked for high power machines for the grinding of rolling mill rolls and large machine cutters. Not much is being done in heavy forgings and castings. Armour plate for the new cruisers is being made by one local firm, but the quantity specified for vessels of this class is comparatively small. Vickers Limited are busy on tanks, and are also doing other work for the Services. They have pointed out during the past week that these orders do not come from Rumania, but from the British Government. In the finished branches there is a considerable contraction of business, especially in connection with the overseas markets. The file and saw trades, which were active and progressive before the end of last year, have lost ground, and the majority of makers report that things have become quieter, and that orders are difficult to obtain. Firms engaged on engineers' small tools also find that they have less work in hand than they had in December. In summing up the situation generally it has to be remembered that the month which has just closed is rarely a busy one, so that the outlook may not be so bad as might be imagined.

Cutlery and Plate.

A new feature with regard to the cutlery trade is the growing competition of the Continent in stainless table knives. These goods are now being made in Germany, France, Belgium, and Sweden, and favourable reports have been received as to their quality. It is not thought, however, that they will be able to undersell the Sheffield products, for which there is a large and steady demand. Trade in pen and pocket knives, sciasors, pruning knives and shears is on a moderate scale. The electro-plate trade has experienced a resumption of the buying of spoons and forks at a much earlier date than last year. In hollow-ware, however, the demand continues quiet. There has recently been a rise in the market for nickel, as a result of which the price of nickel silver as supplied to the electro-plate trade has been advanced a penny per pound.

Figures of Production.

The falling off in the commercial steel trade last year is shown by the figures, which are now available. The quantity of steel ingots and castings produced in the Sheffield district was 1,031,400 tons, as compared with 1,163,800 tons in 1923, and 980,200 tons in 1920. Lincolnshire's total was 466,200 tons, or about 73,000 tons less than in the previous year. The local output of steel in December showed a decline of 34,000 tons as compared with November, and 15,000 tons as against December, 1923.

An Arbitration Result.

The matters in dispute between the Sheffield Forge and Rolling Mills Company, Limited, and its workmen, which recently brought the works practically to a standstill, were referred to arbitration, the court consisting of three representatives of each side, with Sir William Ellis, managing director of John Brown and Co., Limited, as independent chairman. The court has now issued its findings. One question referred to the arbitrators was the basis of payment for night work. The firm claimed that six and a-half shifts should be paid, as against seven and a-half shifts as heretofore. The court finds that the firm has failed to establish this claim, and decided "that the present system of payment for night work under existing conditions of employment shall remain unaltered." In respect of the firm's claim for a 12½ per cent. reduction, which 12½ per cent. is now paid in the form of a bonus added to piecework rates, the court finds that the present system of bonus payment is cumbersome and complicated, and decides that it shall be abandoned and a flat rate bonus of 3/4 per man per shift of eight hours be substituted, covering all the classes of workmen included in the terms of reference. This bonus is to be subject to the customary overtime payments, and is to operate from the week commencing March 1st next.

Colliery Matters.

Progress is reported at Brodsworth Main Colliery, near Doncaster, where the new third shaft was worked for the first time last week. At present the shaft extends only to the Barnsley seam, but from the other shafts at the colliery it is hoped shortly to work the Parkgate seam. In view of the rapid growth of the North Nottinghamshire coalfield, the Mansfield and District Light Railway Company is seeking powers to extend its system of tramways to Clipstone, Rainworth and Blidworth. A Ministry of Transport inquiry into the application was held last week. There was considerable opposition from public bodies, the Bolsover Colliery Company, and the Duke of Portland, on the grounds of the unsuitability of the roads, the period of five years asked for the carrying out of the works, and the road widenings which would be necessitated. On behalf of the applicants it was stated that the number of passengers carried had gone up from just over two millions in 1901 to over six and a-quarter millions last year. Since the Order of 1920, the circumstances had entirely altered, for now the Clipstone colliery was established 3000 men were to be employed there, and 1000 houses would be built; at Rainworth 400 houses had been built, and a population of about 3000 gathered together; while a mile distant, at Blidworth, a new pit was being sunk, 1000 houses were to be built, and eventually there would be a new population.

Sheffield Electricity Contracts.

The Sheffield electricity undertaking is one of the most progressive and successful departments of the Corporation, and the Committee has just agreed, at the request of the Finance Consultative Committee, to the sum of £50,000 being taken from the accumulated revenue and applied in aid of next year's city rate. The Committee expresses the view that it is not sound policy to appropriate large sums from the revenue of trading departments in aid of the rates, but agrees to the present transfer in view of the special circumstances of the time. The progress of the department is shown by the fact that, month by month, extensions of mains involving the expenditure of a good many thousand pounds are authorised. This month the Committee recommends the acceptance of the following among other contracts:—James Laver and Sons, erection of a transformer sub-station on the Manor housing estate, £1167 3s. 6d.; A. Reyrolle and Co., Limited, supply and delivery of forty-three panels of 11,000-volt three-phase extra high-tension sub-station switchgear, £7975 10s.; the British Electric Company, Limited, eighteen 100 kVA single-phase outdoor type transformers, £2122 4s.; the Davenport Engineering Company, Limited, supply, delivery and erection of two natural draught water cooling towers for the Neepsend generating station, £8336. Another Corporation item of interest is that the Tramways Committee recommends the acceptance of a tender of Brown Bayley's Steel Works, Limited, for the supply of 500 steel tramcar tires at 64s. 9d. each.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Iron Trade.

THE Cleveland pig iron trade presents few new features of moment. There is still not a sign of a renewal of activity in any branch, and it is simply a case of marking time. The disposition on the part of buyers to make forward contracts, which was such an encouraging feature of the trade a couple of months ago, has entirely disappeared, and such business as is arranged is simply for prompt delivery to cover immediate requirements. Hope, however, has not been abandoned. There is still a firm belief that 1925 will be a better year than 1924, but the volume of trade thus far has been of very disappointing proportions, and at some works stocks must be increasing. All makers are anxious for fresh orders and have cut prices to the bone in order to get them. There seems to be a little more inquiry from the Continent, but really there has not been much business booked. However, the position in that direction is a trifle more hopeful, and certainly there is room for improvement. A cargo of 2000 tons of special Cleveland iron was shipped this week to the United States, and a further cargo is being loaded, but this is all special iron and apparently there is still no chance of ordinary Cleveland or hematite iron going across, though inquiries are still being circulated. The price of No. 3 G.M.B. Cleveland pig iron is steady at 79s. per ton, No. 1 being 84s.; No. 4 foundry, 78s.; and No. 4 forge, 77s.

Hematite Pig Iron.

East Coast hematite makers appear to be worse situated than Cleveland producers, and are very keen for new orders. Some amazingly low figures have been quoted for mixed numbers of hematite c.i.f. Antwerp, and a few orders have come in, but these are all going to one firm, and other producers who regard 86s. per ton as their minimum have to be chiefly content with the small volume of home business.

Ironmaking Materials.

Consumers of foreign ore have ample stocks to cover their present needs, and there are very few inquiries on the market. Best Rubio ore is nominal at 22s. per ton c.i.f. Tees. The coke market is weak and, although makers of the best Durham furnace cokes still quote 24s. 6d. per ton delivered at the works, sales are reported at 24s.

Manufactured Iron and Steel.

There is no improvement in the manufactured iron and steel trade. Foreign competition is still very keen, and large quantities of semi-finished material are being imported. Some of the local steel mills have been laid idle through slackness of orders, and in this respect the position is most disappointing. Manufacturers, however, are refusing to cut prices any further.

The Coal Trade.

The lack of demand in the Northern coal trade is daily becoming more pronounced, and with few orders actually being placed the position is very disappointing. Fitters have reason to believe that merchants hold a fair number of orders, and are only putting them out for day-to-day requirements, but even under these conditions the total requirements are much below what could be dealt with, and consequently while sellers fight a hard battle against a maintenance of late values, the scarcity of business is all against a maintenance of late values, and the February position thus becomes somewhat discouraging. The outlook is, in fact, extremely dull, and there is a feeling that this year will be worse than last year. No one can discern a gleam of light so far as the export trade is concerned. Idle time is becoming more general, despite the previous closing down of pits. More men have received notice to terminate their engagements at the end of this week in Northumberland, 700 men being affected at the Hazelrigg Colliery, near Newcastle. The economic position of the industry is further illustrated by the ascertainment which governs wages in Northumberland. This shows that in the county wages would have again been lower in February—namely, 69.30 per cent. on basis rates—but for the safeguarding clause in the national agreement of 100 per cent. minimum on basis wages. For immediate deliveries sales of best Northumberland steams have been made at 18s. 6d. per ton, but for the end of the month there are buyers at 18s. 4½d., but these values appear to be the best obtainable. Durham gas coals are steady, best qualities still commanding 21s. per ton. Unscreened and coking coals remain a quiet trade, but owners hold steadily against further reductions and quote 17s. 9d. to 18s. 6d., according to descriptions. Bunker coals are in quiet demand, but nominally steady at from 18s. to 19s., according to grade. The demand for coke is very slow, although there is some interest in the trade shown by German buyers, but until definite business offers prices show no movement, and on the whole the trend of the market is easier.

Wages in Iron and Steel Trade.

Wage adjustments under the sliding scale arrangements governing different branches of the iron and steel trade are announced this week. With respect to the North of England manufactured iron trade the report of Messrs. Price, Waterhouse and Co. is that the output of bars and angles during November and December last was 2492 tons, compared with 2473 tons in the previous two months. The average net selling price is certified at £12 5s. 10.97d. per ton, as compared with £12 4s. 9.89d. per ton, the variation being so small that there will be no change in puddling and other forge and mill wages during the ensuing two months. With regard to the scale for steel smelters, the quarterly ascertainment shows the average net selling price for the three months ended December 31st to be £9 9s. 7.69d. per ton, which carries with it a wage reduction of 2½ per cent. The scale percentages for the current three months will therefore be 41¼ per cent. basic and 16¾ per cent. acid, and will operate as from Sunday, February 1st.

SCOTLAND.

(From our own Correspondent.)

No Improvement.

GENERAL conditions in the steel, iron, and coal markets have not appreciably altered since last week. Business, on the whole, is extremely disappointing and the outlook dull and unsatisfactory. Prospects of a trade revival appear to be as remote as ever, and manufacturers have to be content with occasional orders of comparatively small dimensions. The shipbuilding and allied trades are not issuing specifications to the anticipated extent, while a further adverse circumstance is the uncertain labour attitude. Continental competition continues keen, and, in addition, Scottish producers are up against keen English quotations for similar material. Many establishments are operating far below capacity, and there is nothing to indicate an early return to comparative activity.

Pig Iron.

With the consuming trades in a state of inactivity, the demand for pig iron remains far below normal, and even with outputs on a very low level makers still find stocks on the increase. Competition from the Continent has not been quite so apparent, and this has been especially the case in basic iron, but local makers have not benefitted to any extent. Buying all round is exceptionally small, and the prices offered extremely keen. Nominally quotations show no alteration, but a weaker tendency is noticeable and there is little doubt that a good order could be advantageously placed at present.

Poor Demand for Plates and Sections.

The effect of a slowing down in the shipbuilding industry is seen in the small amount of business being done in plates and sections. The former in particular meet with very little business, and specifications are far from numerous. Business in sections has derived some orders from structural engineers and others, and is a little better off than business in plates, but is still far below normal. So far as export is concerned, makers are still handicapped by cheap continental quotations.

Activity in Light Sheets.

There has been practically no falling off in activity in light steel sheets. Ordinary black sheets are well booked up, while the galvanised descriptions are increasingly busy after a temporary lull in buying. Prices of the latter are very firm at £18 10s. per ton for 24 b.g. f.o.b. Glasgow, and may appreciate.

Bar Iron.

The volume of business in bar iron is poor. Export inquiries have been more numerous, but actual business is small in comparison. Re-rolled steel also is poorly supported, though there are occasional good lines in the market. Owing to the scarcity of orders for iron many of the mills are still making steel bars from imported billets.

Coal.

The depression in the coal trade is not appreciably tighter and practically all descriptions of fuel are greatly in need of fresh business. Shippers have great difficulty in securing prompt orders from abroad, while forward business is almost at a standstill. German competition is still keen, and the increasing production in that country is most detrimental to the trade here. Apart from prime Lanarkshire splints there is little movement of any consequence in the market. This fuel is heavily booked for shipment to West Italy and the River Plate. Lanarkshire ells and steams from Fifeshire and the Lothians have occasional orders, but they are not large enough to affect the market to any extent. Small stuffs are especially weak, and it is reported that considerable quantities have been sold at cheap prices for shipment to West Italy. Aggregate shipments during the past week amounted to 234,199 tons, against 239,219 tons in the preceding week and 283,255 tons for the same week last year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Position.

THERE has not been much activity in the steam coal export trade during the past week. The conditions all round remain quiet, much to the disappointment of exporters and colliery salesman, and instead of values inclining to improve, the tendency is towards increased irregularity, especially as bad weather has delayed tonnage and most colliery undertakings have fairly heavy stocks. This latter circumstance, of course, means that the question of empty wagons with most concerns becomes a very pressing one, and salesmen are forced to make concessions to possible buyers who can take quick delivery. Probably later, when tonnage which has been held up by the gales makes its appearance, the position of many collieries will improve. It is quite possible that the second half of the month will be better than the first half, as exporters who have commitments to execute have to reckon that this is a short month, and they will make efforts to get away their shipments rather earlier. At the same time, the inquiry from abroad is not at all cheerful from the point of view of volume, and the prices that are offered for supplies are anything but favourable. The demand for single cargoes is far from active, and as regards larger quantities, the only inquiries in the market consist of one from the Algerian State Railways for 30,000 tons of large and a similar quantity of smalls, for shipment over the next three months, while the French State Railways have asked for tenders for supplies over the same period.

South Wales Miners' Proposals.

The Executive of the South Wales Miners' Federation met at the end of last week to consider recommendations to be made to a South Wales conference to be held at Cardiff on the 21st inst., preparatory to the conference of the Miners' Federation of Great Britain, which will take place on the 26th inst. The recommendations which the Executive decided upon are fairly sweeping, and are that the minimum precentage above the wages paid in 1914 be increased from 33⅓ per cent. to 43⅓ per cent.; that the present subsistence rate of wages be increased to 9s. per shift; that joint representation by the owners and the workmen shall be made to the Government to re-enact Part 2 of the Mining Industry Act, 1920; that the reforms in the auditing of the colliery accounts asked for last year be insisted upon; that workmen in receipt of partial compensation shall be paid full subsistence rate of wages; that the provision in the present agreement for carrying forward deficiencies be deleted; that membership of the workmen's organisations be a condition of work at the collieries, and that workmen shall be supplied by the colliery owners with all explosives necessary. With regard to the recommendation that the minimum percentage should be increased, the effect of the Executive's proposal if adopted would be to raise the minimum to 59⅓ per cent. on the 1915 standard or an increase of about 1s. to 1s. 2d. per day to all day workers, while the earnings of piece-workers would be advanced up to 2s. and more per day. Part 2 of the Mining Industry Act of 1920 deals with the appointment of joint pit committees. When they had the opportunity to operate this, the workmen declined, but apparently they are now in favour of it.

Anthracite Colliery Deal.

Another important transaction in anthracite colliery property in this district is reported, the United Anthracite Collieries Company, Limited, having acquired the Pentremawr Colliery, Pontyberem. The deal is understood to involve a sum of about half a million pounds. The Pentremawr Colliery has an output of about 600 to 700 tons per day, and employs about 800 men, the quality of the coal produced being of the best. It is estimated that the production of the collieries in the new combine will now amount to upwards of 5000 tons per day, which is approximately 50 per cent. of the output of the anthracite section of the coalfield in this district. The United Anthracite Collieries Company now owns practically all the colliery undertakings of importance in the Gwendraeth Valley, with the exception of two concerns.

Tin-plate Industry.

The outlook in the tin-plate industry is regarded rather more hopefully than of late, and at any rate it is cheering to note that so far as the Llanelly district is concerned, resumption of work has taken place at two tin-works which have been closed since the middle of December. This means that practically all the works at this town are now operating, though in most cases part time only is being worked. The Welsh Steel and Sheet Manufacturers' Association has decided, owing to the continued low position of the basis of the sliding scale, to continue the *ex gratia* bonus of 7½ per cent. for a further three months, viz., to the end of April.

Copper Trade Depression.

The position in the Swansea copper industry is far from being satisfactory, and is causing grave anxiety to a number of workmen, of whom about 300 are out of employment. The three works at Swansea and the Margam Works at Port Talbot now belong to one ownership, and in order to increase efficiency and recover the old-time prosperity, severe changes in administration have been found imperative. The consequence is that in carrying out these schemes many workmen have suffered, and among the first is a number of the older men, many of whom have been all their lives in the industry. In their case the question of finding alternative employment is a very difficult one. The matter is receiving the attention of the Transport and General Workers' Union, leading officials of which organisation have been in Swansea to discuss the situation with the local officials.

Current Business.

Extremely little business has been done during the last few days, and the tone of the market for steam coals generally is quiet. In some sections recent prices are maintained, but in others values are on the easy side, especially for prompt loading. Best Admiralty large coals rule about 26s. 9d. to 27s., while superior smalls retain their steadiness, owing to production having been interfered with of late, as the result of less active shipments. Anthracite coals show no change, and on the whole are fairly steady.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. G. MONFORT, of Schneider et Cie. (Le Creusot), has just been elected President of the Chambre de Commerce Française de Londres.

WE are informed that Richard Lloyd and Co., Limited, of Steelhouse-lane, Birmingham, have acquired the goodwill of Stockton and Bunn, Limited (in liquidation), of 11, Queen Victoria-street, London, E.C. 4, which will be maintained as a London office.

WE are asked to state that the patent rights, goodwill and assets of the Alpe Patent Couplings, Limited, 41, Livery-street, Birmingham, have been taken over by Ed. J. Hardy and Co., Limited. The business of the Alpe Company will be moved to the latter company's works at Coventry and Birmingham, where the Alpe couplings will be manufactured under the supervision of Mr. R. J. Alpe, the patentee. Mr. Joseph A. Oldbury will be managing director of both concerns.

WE learn that Mr. E. W. Dickinson, M.I.E.E., is retiring on superannuation at the end of this month from the position of power engineer and superintendent of the Greenwich power station of the London County Council, a position which he has occupied since 1906. We understand that Mr. Dickinson proposes to devote himself to consulting practice, with special reference to power station operation, including the economical combustion of fuel. His address is 6, Uhundi-road, Blackheath, S.E. 3. Telephone number, Greenwich 60.

LAUNCHES AND TRIAL TRIPS.

SHEAF WATER, steel screw collier; built by the Blyth Shipbuilding and Dry Docks Company, to the order of the Sheaf Steam Shipping Company, Limited; dimensions, 330ft. 5in. by 42ft. 11in. by 26ft. 9in.; to carry 4050 tons. Engines, triple-expansion, 23½in., 38in., 64in. by 42in. stroke; constructed by the North-Eastern Marine Engineering Company, Limited; trial trip, January 22nd.

No. 1255, single-screw motor ship; built by Swan, Hunter and Wigham Richardson, Limited, to the order of the Hopemount Shipping Company, Limited; dimensions, 400ft. by 55ft. 3in. by 29ft. 6in.; 5075 gross tonnage. Engines, six-cylinder marine oil two-cycle single-acting; constructed by the builders; launch, January 23rd.

FEDERIKO GLAVIC, cargo steamer; built by Workman, Clark and Co., Limited, to the order of Dubrovacka Parobrodska Plovidba (A.D.), of Dubrovnik; dimensions, 435ft. long; 5300 gross tonnage. Engines, inverted direct-acting triple-expansion; constructed by the builders; launch, January 28th.

RYDAL HALL, single-screw steamer; built by Barclay, Curle and Co., Limited, to the order of Ellerman Lines, Limited; dimensions, 416ft. 6in. by 54ft. 9in. by 32ft.; 7000 gross tonnage. Engines, one set of triple-expansion, 23½in., 40½in., 71in. by 48in. stroke; constructed by the builders; trial trip, January 29th.

JUDGE KENEFICK, steamer; built by Earle's Shipbuilding and Engineering Company, Limited, to the order of the Eastern Steamship Company, Limited, of Canada; dimensions, 258ft. by 44ft. by 20ft.; 2510 tons deadweight. Engines, triple-expansion, 17in., 28in., 46in. by 33in. stroke, pressure 180 lb. constructed by the builders; launch, January 30th.

CATALOGUES.

ADAM HILGER, Limited, 75a, Camden-road, N.W. 1.—General catalogue.

CARRON COMPANY, Carron, Falkirk.—Sectional catalogue of haulage gears.

JOHN PICKLES AND SON (Engineers), Limited, Hebden Bridge.—Booklet on woodworking machinery.

JOHNSON AND PHILLIPS, Limited, Charlton, S.E. 17.—List T.T.S. on transformer tapping switches.

H. MORIN, 11, Rue Dulong, Paris (17e).—Booklet of various specimens of drawing and tracing paper.

WM. JESSOP AND SONS, Limited, Brightside Works, Sheffield.—Booklet on Jessop's steels for all purposes.

THERMIT, Limited, 155, Church-road, Battersea, S.W. 11.—Booklet describing Eel brand anti-friction metal.

TWINING MODELS, Limited, Northampton.—Booklet describing various models, with a large number of art plates.

A. AND J. MAIN AND CO., Limited, Australia House, Strand, W.C. 2.—Booklet on Main's Kelvin all-iron railway palisading.

POWER GAS ECONOMY COMPANY, 50, Wellington-street, Glasgow.—Illustrated descriptive leaflet on the Hunter gas valve.

THE BRITISH STEEL PILING COMPANY, Limited, 54A, Parliament-street, S.W. 1.—Booklet describing the Erie steam shovel.

GEORGE KENT, Limited, 199, High Holborn, W.C. 1.—Folder illustrating the outside and the inside of the Kent Torrent meter.

EDGAR ALLEN AND CO., Limited, Imperial Steel Works, Sheffield.—Illustrated descriptive booklet entitled "Drill Data."

THE BILLING TOOL COMPANY, 303, High Holborn, W.C. 1.—Illustrated price list No. 20 of the various B.T.C products for engineers.

DOWDINGS MACHINE TOOL COMPANY, Bush House, Aldwych, W.C. 2.—Monthly list of new and second-hand machine tools for disposal.

KLAXTON, Limited, 39, Blandford-street, W. 1.—Booklet showing the Klaxton system of danger warning in factories, workshops, &c.

WILLIAM BEARDMORE AND CO., Limited, 3, Manchester-street, W. 1.—Pamphlet dealing with the Beardmore Caprotti locomotive valve gear.

THE CRESSALL MANUFACTURING COMPANY, 40/41, Staniforth-street, Birmingham.—Leaflet describing the Cressall steel-jacketed unit heater.

WILLIAM BOBY AND CO., Limited, 62 and 64, Brook-street, W. 1.—Folder illustrating and describing the Boby water softener, lime-soda gravity type.

HADFIELDS, Limited, East Hecla and Hecla Works, Sheffield.—Illustrated catalogue No. 152, on stone and ore breaking, screening and elevating machinery.

SIEBE, GORMAN AND CO., Limited, 187, Westminster Bridge-road, S.E. 1.—General catalogue of breathing and other safety, protective, and first-aid appliances.

SMITH BROTHERS AND CO. (Hyson), Limited, Hyson Green Works, Nottingham.—Pages 32 to 45 for the loose leaf steam fitting catalogue. With illustrations and price lists.

MARINE AND SMALL CRAFT EXHIBITION AND CONGRESS.—It is announced that an exhibition of small marine craft and yachts will be held at the Royal Agricultural Hall, Islington, from March 18th to April 4th next. The purpose of this exhibition and of the congress which will be held while it is open is to popularise yachting and boating, and craft representative of both will be shown. Further particulars regarding this event can be obtained from the exhibition manager at 13, Victoria-street, S.W. 1.

PROPOSED NEW CEMENT FACTORY.—The foundation stone of what, it is claimed, will be the largest Portland cement works in the United Kingdom will be laid at Bevans, Northfleet, in the first week of March. The project is being put in hand by the directors of the Associated Portland Cement Manufacturers, Limited, to enable them to cope with the rapidly increasing demand for cement which has been brought about by the Government housing experts' recent pronouncement in favour of concrete construction. The new factory, the construction of which will be proceeded with night and day in order to ensure completion at the earliest possible moment, is to have a productive capacity of no less than 10,000 tons of cement a week, or 500,000 tons a year, which is nearly equal to one-sixth of the total cement production of Great Britain to-day. The new factory will be favourably situated. Its site will be several square miles in extent and in it there is what is described as being an almost unlimited supply of raw materials—chalk and clay—which will be mixed in the quarries themselves and pumped through pipes to the manufacturing plant. For many decades a smaller factory, now in process of demolition, has been producing cement on this site. There is a wide frontage on the river Thames, and a 600ft. long jetty is to be built to enable large steamers to come alongside at all states of the tide. They will arrive loaded with coal and load up with cement for coas wise trade and export.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
Native	17/6 to 24/-
(1) Spanish	23/-
(1) N. African	23/-
N.E. COAST—	
Native	—
Foreign (c.i.f.)	22/-

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	4 13 6	—
No. 1 Foundry	4 11 6	—
No. 3 Foundry	4 9 0	—
N.E. COAST—		
Hematite Mixed Nos.	4 6 0	4 6 0
No. 1	4 6 6	4 6 6
Cleveland—		
No. 1	4 4 0	4 4 0
Silicious Iron	4 4 0	4 4 0
No. 3 G.M.B.	3 19 0	3 19 0
No. 4 Foundry	3 18 0	3 18 0
No. 4 Forge	3 17 0	3 17 0
Mottled	—	—
White	—	—
MIDLANDS—		
(3) Staffs.—		
All-mine (Cold Blast)	10 10 0	—
North Staffs. Forge	3 17 6	—
,, ,, Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	3 15 6	—
,, Forge	3 10 6	—
(3) Derbyshire—		
No. 3 Foundry	4 1 0 to 4 2 0	
Forge	3 16 6	—
(3) Lincolnshire—		
No. 3 Foundry	4 2 5	—
No. 4 Forge	3 17 6	—
Basic	4 0 0	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	5 2 6 (a)	—
	5 7 6 (b)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	12 0 0	—
Best ,,	—	—
N.E. COAST—		
Common Bars	12 0 0	—
LANCS.—		
Crown Bars	13 0 0	—
Second Quality Bars	12 0 0	—
Hoops	15 0 0	14 15 0
S. YORKS.—		
Crown Bars	13 0 0	—
Best ,,	13 10 0	—
Hoops	14 10 0	—
MIDLANDS—		
Crown Bars	12 15 0	—
Marked Bars (Staffs.)	15 0 0	—
Nut and Bolt Bars	11 15 0	—
Gas Tube Strip	13 0 0 to 13 2 6	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	13 0 0	—
Ship Plates, ½in. and up	9 15 0	—
Sections	9 10 0	—
Steel Sheets, 3/16in. to ½in.	12 0 0	—
Sheets (Gal. Cor. 24 B.G.)	—	18 10 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	9 5 0	—
Angles	9 0 0	—
Boiler Plates	13 0 0	—
Joists	9 5 0	—
Heavy Rails	9 10 0	—
Fish-plates	13 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	9 10 0	—
Soft Billets	8 10 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	9 0 0†	—
Light ,,	9 5 0 to 9 10 0	
Billets	8 0 0 to 11 0 0†	
MANCHESTER—		
Bars (Round)	9 15 0 to 10 0 0	
,, (others)	9 10 0 to 9 15 0	
Hoops (Best)	15 5 0	15 0 0
,, (Soft Steel)	13 15 0	13 10 0
Plates	9 10 0 to 9 15 0	
,, (Lancs. Boiler)	13 0 0	—
SHEFFIELD—		
Siemens Acid Billets	11 10 0	—
Bessemer Billets	13 0 0	—
Hard Basic	9 10 0	—
Intermediate Basic	9 0 0	—
Soft Basic	8 0 0 to 8 5 0	
Hoops	12 0 0	—
Soft Wire Rods	11 0 0 to 11 10 0	
MIDLANDS—		
Small Rolled Bars	9 0 0 to 9 15 0	
Billets and Sheet-bars	7 5 0 to 7 10 0	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	17 2 6 to 17 5 0	—
Angles	9 5 0	—
Joists	9 5 0	—
Tees	10 5 0	—
Bridge and Tank Plates	9 15 0	—
Boiler Plates	13 10 0	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	23/6 to 23/7½
Block Tin (cash)	267 10 0
,, (three months)	265 12 6
Copper (cash)	65 0 0
,, (three months)	66 0 0
Spanish Lead (cash)	37 7 6
,, (three months)	36 15 0
Spelter (cash)	36 8 9
,, (three months)	36 0 0
MANCHESTER—	
Copper, Best Selected Ingots	70 0 0
,, Electrolytic	71 0 0
,, Strong Sheets	96 0 0
,, Tubes (Basis Price)	0 1 1½
Brass Tubes (Basis price)	0 1 0½
,, Condenser	0 1 2½
Lead, English	41 0 0
,, Foreign	39 5 0

FERRO ALLOYS.

(All prices now nominal.)

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/8½ per lb.	
Ferro Tungsten	1/4½ per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£24 0 0	8/-
,, 6 p.c. to 8 p.c. ,,	£23 10 0	7/9
,, 8 p.c. to 10 p.c. ,,	£23 0 0	7/6
,, Specially Refined		
,, Max. 2 p.c. carbon	£43 0 0	16/-
,, ,, 1 p.c. ,,	£52 0 0	17/6
,, ,, 0.75 p.c. carbon	£58 0 0	20/-
,, ,, carbon free	1/5 per lb.	
Metallic Chromium	4/- per lb.	
Ferro Manganese (per ton)	£15 for home, £15 for export	
,, Silicon, 45 p.c. to 50 p.c.	£12 0 0	scale 5/- per unit
,, ,, 75 p.c.	£19 17 6	scale 6/- per unit
,, Vanadium	17/- per lb.	
,, Molybdenum	7/6 per lb.	
,, Titanium (carbon free)	1/- per lb.	
Nickel (per ton)	£175	
Cobalt	10/- per lb.	
Aluminium (per ton)	£130	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	16/9
,, ,, Ell	18/6
,, ,, Splint	19/- to 23/-
,, ,, Trebles	18/-
,, ,, Doubles	17/-
,, ,, Singles	13/9
AYRSHIRE—	
(f.o.b. Ports)—Steam	16/9
,, ,, Splints	19/-
,, ,, Trebles	18/-
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	14/9 to 17/-
Screened Navigation	24/-
Trebles	17/-
Doubles	16/-
Singles	14/6
LOTHIANS—	
(f.o.b. Leith)—Best Steam	16/9
Secondary Steam	16/-
Trebles	17/6
Doubles	16/-
Singles	14/6

ENGLAND.

(8) N.W. COAST—	
Steams	28/6
Household	45/- to 58/4
Coke	30/-
NORTHUMBERLAND—	
Best Steams	18/4½ to 18/6
Second Steams	17/6
Steam Smalls	10/3 to 10/6
Unscreened	15/6 to 16/6
Household	23/6 to 25/-
DURHAM—	
Best Gas	21/- to 21/6
Second	18/- to 18/6
Household	23/6 to 25/-
Foundry Coke	23/- to 23/6

SHEFFIELD—	Inland.	
Best Hand-picked Branch	30/- to 33/-	—
Barnsley Best Silkstone	26/- to 28/-	—
Derbyshire Best Brights	26/- to 31/-	—
,, ,, House	24/- to 26/-	—
,, ,, Large Nuts	22/6 to 25/-	—
,, ,, Small	14/- to 16/-	—
Yorkshire Hards	19/6 to 23/-	—
Derbyshire ,,	19/6 to 22/-	—
Rough Slacks	9/6 to 12/-	—
Nutty ,,	8/6 to 10/6	—
Smalls	4/- to 6/6	—
Blast-furnace Coke (Inland)*	—	—
,, ,, (Export)	f.o.b.	20/9 to 21/9

(9) SOUTH WALES.

CARDIFF—	
Steam Coals :	
Best Smokeless Large	26/9 to 27 -
Second ,, ,,	26/- to 26/6
Best Dry Large	25/6 to 26/6
Ordinary Dry Large	24/- to 24/6
Best Black Vein Large	24/6 to 25/-
Western Valley ,,	23/6 to 24/6
Best Eastern Valley Large	23/- to 24/-
Ordinary ,, ,,	22/6 to 23/-
Best Steam Smalls	16/- to 16/6
Ordinary ,,	13/- to 15/-
Washed Nuts	22/- to 32 -
No. 3 Rhondda Large	27/- to 27 6
,, ,, Smalls	19/- to 20 -
No. 2 ,, Large	22/6 to 23 6
,, ,, Through	18/- to 20 -
,, ,, Smalls	11/- to 13 -
Foundry Coke (export)	40/- to 47/6
Furnace Coke (export)	25/- to 30/-
Patent Fuel	25/- to 27/-
Pitwood (ex ship)	24/6 to 25/-
SWANSEA—	
Anthracite Coals :	
Best Big Vein Large	45/- to 47/6
Seconds	35/- to 37/6
Red Vein	32/6 to 35/-
Machine-made Cobbles	50/- to 55/-
Nuts	50/- to 52/6
Beans	44/- to 45/-
Peas	20/- to 23/6
Breaker Duff	9/- to 9/6
Rubbly Culm	10/- to 10 6
Steam Coals :	
Large	24/- to 25/6
Seconds	22/6 to 24/6
Smalls	11/6 to 14/-
Cargo Through	17/- to 19/-

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. * For blast-furnaces only, 16/9, with fluctuations according to analysis; open market, 18/- to 19/- at ovens. † Latest quotations available. (a) Delivered Sheffield or Glasgow. (b) Delivered Birmingham.

French Engineering Notes.

(From our Correspondent in Paris.)

Unemployment.

THE question of unemployment is beginning to occupy attention, at all events in the devastated regions. In the Lille district alone 10,000 men are out of work, and, as it appears probable that reconstruction operations will be entirely suspended, the situation is becoming serious. It is proposed to send out of the district all the foreign workmen who were induced to come into the country at a time when sufficient hands could not be found to carry out the work. The Federation of Contractors is to meet to discuss what is to be done in view of the decision of the Government to pay for reconstruction work in bonds redeemable in ten years. As the bonds can only be realised at a heavy discount, no one will accept them, and the Federation affirms that unless better conditions are offered all reconstruction work will be suspended, and that would mean that a large army of men would have to find employment elsewhere. Unfortunately, the industrial situation throughout the country generally is so uncertain on account of the money stringency that it will scarcely be possible to absorb all the men from the devastated areas. The Minister for the Liberated Regions is endeavouring to find the funds necessary to prevent what threatens to become a serious crisis.

Iron and Steel Prices.

The depressing effect of over-production on the prices of iron and steel is causing producers to consider the ways and means of checking a competition which may have serious consequences in the early future. The failure of the negotiations with German ironmasters has left little hope to the French of being able to keep up prices in foreign markets, and at home the difficulties are almost as great, for some producers have refused to enter into a combination for the maintenance of selling prices. It appears, however, as if that is likely to be done in the case of pig iron, which has recently been fluctuating in a way that kept off buyers in the belief that an early decline was inevitable, but a recent hardening of values and the announcement that blast-furnace proprietors are about to come to an understanding point to a reorganisation of this branch of industry. Efforts are now being made to stabilise the prices of other metallurgical products on the home market so that makers may be in a better position for dealing with the foreign demand.

Electric Road Traction.

The Union des Syndicats de l'Electricité has been making continuous and persistent efforts to encourage and develop the employment of electricity for road traction, and the increasing economy observable in the periodical trials of vehicles implies that the outlook for electric traction is more reassuring, in the event of the programme of national electrification being carried out on a sufficiently large scale. The Union will shortly issue a complete report upon the trials that were held in October last, when five firms competed in the tests, which consisted of daily runs over circular routes in and around Paris, and of speed trials on the flat and on gradients to ascertain the influence of speed on consumption. In the first of these tests the average consumption per ton-kilometre of total weight varied from 60 to 80 watt-hours in the different categories of vehicles when running in the suburbs. The consumptions over the Paris routes were, in most cases, appreciably less. The consumptions per ton-kilometre of load carried naturally varied much more. On the suburban routes the averages ranged from 140 watt-hours for lorries to 360 watt-hours for the light vehicles, the former being at a speed of 12 kiloms. an hour, while some other vehicles travelled at 18 and 19 kiloms. The consumption of an electric omnibus in Paris was 310 watt-hours per ton-kilometre of load and the average speed was 17½ kiloms. an hour. The competing vehicles were run at various speeds on a level road with a view of ascertaining the most economical speeds in the different categories. Amongst the light cars the consumption ranged from 330 to 365 watt-hours per ton-kilometre of load at speeds of from 20 to 25 kiloms. an hour. The consumptions of the lorries were 80 and 85 watt-hours per ton-kilometre, at speeds of 11 and 13 kiloms., while the consumption of the electric omnibus was 255 watt-hours at 21 kiloms. an hour. The Union des Syndicats de l'Electricité affirms that as the result of the trials a certain number of electric lorries and delivery vans found purchasers, and that in the coming spring electric taxi cabs will be running in Paris. Probably the greatest impetus to electric road traction will be given this year at Grenoble, where it will receive special attention at the International Exhibition of Electricity.

Rail Motors.

The results obtained with the rail motors that were put into service on certain local lines more than a year ago do not appear so far to have warranted a more general employment of the system. Their utility is recognised, and they will no doubt continue to find an application on small local lines where the traffic does not permit of steam locomotives being employed economically. But there is no longer any question of employing petrol locomotives on the main lines, which was regarded as one of the possible developments of the future at a time when the early trials showed a considerable reduction in the cost of hauling loads. The petrol locomotives used for shunting purposes at St. Lazare terminus have not entirely realised expectations. They certainly do not get empty trains away from the sidings so promptly as do the steam engines, and the upkeep and running costs are higher than had been expected. One of the petrol locomotives at the Gare St. Lazare was recently destroyed by fire. That risk, however, is not confined to petrol engines, for the same thing happened to an electric locomotive on the Invalides line. The utility of the petrol motor is dependent on circumstances, and in Belgium it has been decided to put a number of them in service on local railways.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

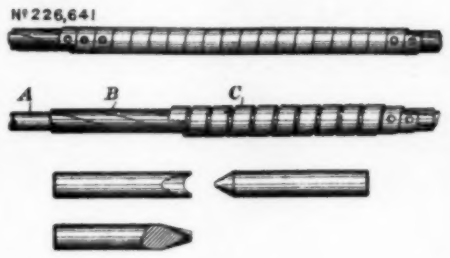
The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

TELEGRAPHS AND TELEPHONES.

226,641. October 26th, 1923.—IMPROVEMENTS IN THE MANUFACTURE OF CONTINUOUSLY LOADED ELECTRIC CONDUCTORS, The Western Electric Company, Limited, of Connaught House, Aldwych, W.C. 2, and James Thomas Griffin, of 12, Park-drive, Golders Green.

Where cable loading takes the form of a tape wound round the main electrical conductor great difficulty has been experienced in fixing this tape to the conductor, and an object of this invention is to provide an improved method of performing this operation. In the past, mechanical fixing, such as tying or clipping, has been adopted. Soldering or brazing has also been employed, but all these schemes are unsatisfactory. According to this

Nº 226,641



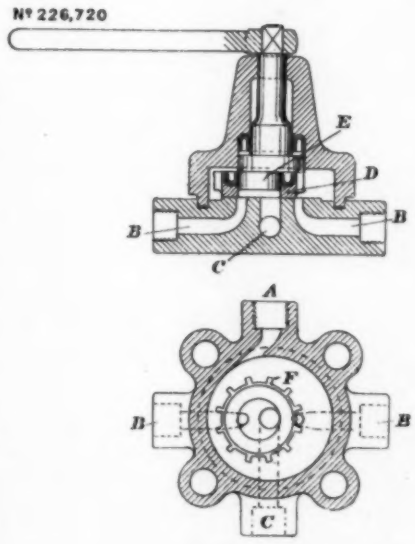
invention, the jointing operation is carried out by electrical welding. Two electrodes are used as shown in the bottom illustration. These electrodes are firmly pressed into contact with the taped conductor, and the necessary welding current is made to flow for the requisite space of time. This process makes a neat weld, and the various disadvantages of the other methods are obviated. Preferably, the welding circuit is made and broken at a point other than that where the electrodes make contact with the work. In the upper illustration, the welding spots are shown at the end. In the middle illustration the internal conductor is composed of a metallic wire A, which is surrounded by metallic tapes B. The loading tape C is welded to the tapes B without in any way affecting the conductor A.—*January 1st*, 1925.

TRANSMISSION OF POWER.

226,720. April 8th, 1924.—HYDRAULIC VALVES, H. Crowe, 4, Balmoral-terrace, Saltburn-by-the-Sea.

In this hydraulic operating valve the pressure supply is at A. B B are the branches connected with the machine to be controlled, and C is the exhaust. The valve takes the form of a

Nº 226,720



ring D and the pressure holding it on to the face is partially balanced by the piston E. The piston is excentric to the spindle, and is used to move the valve across the ports. The valve ring is provided with projections F, against which the water impinges and gives it a rotary motion that prevents the faces being scored. —*January 1st*, 1925.

MEASURING AND TESTING INSTRUMENTS.

226,650. November 9th, 1923.—IMPROVEMENTS IN ELECTRICITY METERS, Measurement, Limited, and Frank Holden, both of Fitzalan-street Works, Kennington, S.E. 11.

This invention relates to electricity meters, and has for its object to enable ampère-hour or quantity meters of the mercury motor type to be converted into or used as watt-hour or energy meters without involving any reconstruction or reorganisation of the meter, so that it will thus be available for use either as a quantity or as an energy meter, according to any particular requirements. A variable resistance is combined with the meter. This resistance consists of mercury contained in the chambers A and B, in which conductors C and D are placed. The chambers are bridged by the bent conducting bar D, which can revolve. A bar E, which is also free to revolve, is mounted above the mercury chamber, and at the end of this bar there is a light coil F. In the diagram of connections the meter is shown at H, and an external shunt at J. It will be seen that the coils F are connected in series with a resistance G across the supply mains, and the arrangement is such that as the voltage increases the members E will be pulled round so as to move the member C in such a direction that the distance between this member and the

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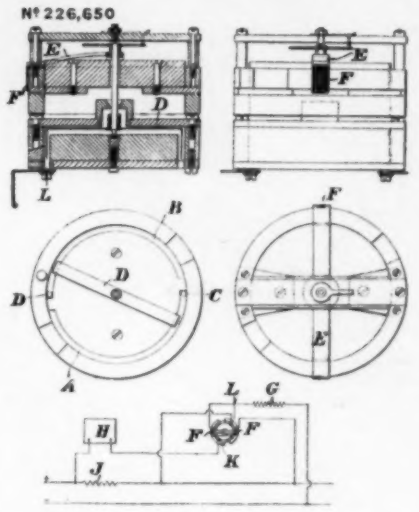

contacts K and L decrease, thus decreasing the resistance of the motor circuit, with consequent increase in the speed of the motor, and by properly proportioning the parts it is possible to obtain more or less accurate compensation for the changes in voltage.—*January 1st*, 1925.

CRANES AND CONVEYORS.

226,745. June 23rd, 1924.—PULLEY BLOCKS, W. C. Trout, Lufkin Foundry and Machine Company, Lufkin, Texas.

In this pulley block the sheaves are formed as rings A A, which run on roller bearings B B. The housing C is made in

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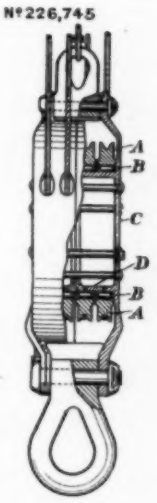

two symmetrical parts, and completely encases the sheaves. The hollow boss D provides a race for the roller bearings and also forms a receptacle for a lubricant.—*January 1st*, 1925.

LIGHTING AND HEATING.

226,661. November 26th, 1923.—LIGHTING MAGNETO FOR VEHICLES, Emil Baumgartner, of Bienne, Switzerland.

The lighting generator described in this specification is driven

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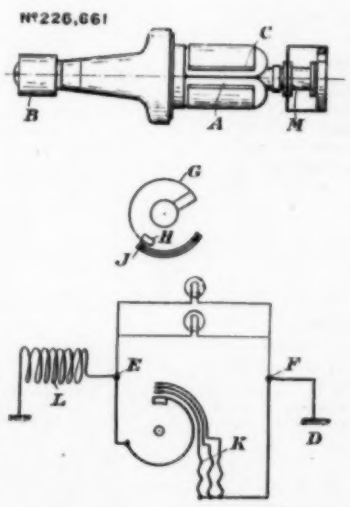


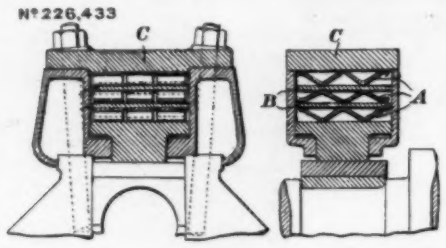
by a wheel of a motor vehicle. The rotor is shown at A, and it is driven by a friction roller B. One end of the rotor winding C is connected to the metal work D, and the other end to the

terminal E of the lighting circuit, the other terminal being shown at F. At the end of the shaft is a short-circuiting device, which is operated by centrifugal force. It consists of a flat spring G, which is attached to a light weight H, which acts upon insulated contacts J, and so varies the shunt resistances K, in accordance with the speed, these shunt resistances being connected across the field L, as shown. The shunt resistances are apparently mounted on the rotor shaft at M.—*January 1st, 1925.*

MISCELLANEOUS.

226,433. May 21st, 1924.—SUGAR CANE MILLS, C. McNeil, Colonial Ironworks, Helen-street, Govan.

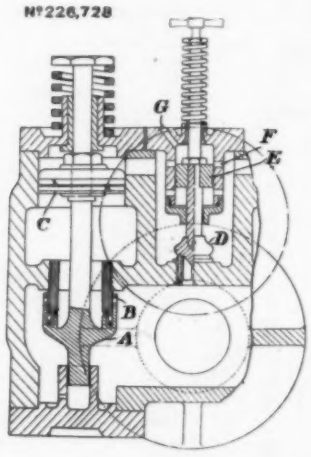
In this relieving gear for sugar cane mills the spring action is provided by a series of corrugated plates A, which are separated



by distance pieces B and are held down by a bolster C and king bolts in the usual manner. In the specification several alternative designs of spring plate are illustrated.—*December 24th, 1924.*

226,728. May 3rd, 1924.—SAFETY VALVES, Babcock and Wilcox, Limited, and Sir J. Kemnal, Babcock House, Farringdon-street, London.

The object of this invention is to provide a safety valve in which the faces are screened from the cutting action of the steam. The valve A is subject to the boiler pressure on the lower side. It takes the form of a sleeve provided with ports B, which



register with other ports in the seating when the valve is opened. The position of the ports is such that the steam flowing through them is directed clear of the seating faces. The valve is opened, against the pressure, by steam acting on the piston C, when the pilot valve D opens. When the pilot opens the piston E masks the ports F, but when it is closed these ports are open and the upper face of the piston C is then in communication with the atmosphere by way of the passage G.—*January 1st, 1925.*

226,731. May 23rd, 1924.—LIQUID FUELS, Badische Anilin and Soda Fabrik, of Ludwigshafen-on-Rhine, Germany.

This invention relates to improvements in the production of liquid fuels, and is intended to increase the usefulness of organic liquids which may be used as fuels. The inventors' correspondents have found that such improvements are effected by adding to a liquid fuel a small amount of a carbonyl compound of iron, and that the fuels so obtained are particularly suitable for use as motor fuels. The quantity of the iron carbonyl compound best suited to produce the desired effect varies according to the particular fuel to which it is added, and the special use for which it is intended. Generally speaking, between about one-tenth and 1 per cent. will be sufficient. As an example, a motor car fitted with a six-cylinder motor, having a compression ratio of 1 to 5.8, and driven with ordinary spirit of 0.72 specific weight, showed heavy "knocking," it is said, especially when running with full load and reduced rotation of the motor, for example, up hill. This "knocking" was completely eliminated when a small addition of iron carbonyl was made to the fuel.—*January 1st, 1925.*

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

DIESEL ENGINE USERS' ASSOCIATION.— The Engineers' Club, Coventry-street, London, W. 1. Paper, "Submarine Engines and High-speed Heavy-Oil Engine Electric Generating Sets," by Mr. P. A. Holliday. 3.30 p.m.

INSTITUTE OF MARINE ENGINEERS.—Hotel Victoria, London, W.C. 2. Annual conversazione. 6.30 p.m.

INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—198, West-street, Sheffield. Joint meeting with the Sheffield Metallurgical Association. Paper, "Fuel and its Efficient Utilisation," by Dr. C. H. Lander. 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Students' visit to the Albion Motor Car Works. 7.30 p.m.

INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Metallurgical Department, University College, Singleton Park, Swansea. Paper, "Season Cracking and its Prevention," by Dr. H. Moore. 7.15 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, Westminster, London, S.W. 1. Informal meeting. Discussion on "Gear Production Machinery." 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS: YORKSHIRE BRANCH.—Philosophical Hall, Leeds. Paper, "Anti-friction Bearing Applications for Heavy Duties," by Mr. J. B. Dahlerus. 7.30 p.m.

INSTITUTION OF PUBLIC LIGHTING ENGINEERS.—Visit to the Hammersmith works of the General Electric Company, Limited. Meet at Magnet House, Kingsway, W.C. 2, at 1.45 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Honorary members' lecture, "Milestones in the Development of the Prime Mover Locomotive," by Mr. Loughnan Pendred. 7.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Literary and Philosophical Society, Newcastle-upon-Tyne. Paper, "The Internal Combustion Locomotive," by Mr. J. W. Hobson. 7.30 p.m.

PHYSICAL SOCIETY OF LONDON.—Imperial College of Science and Technology, South Kensington, London, S.W. 7. Annual general meeting. Address on "A System of Electrical Measurements," by Mr. F. E. Smith. 5 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Discourse, "The Forces of Law and Order in a Primitive Community," by Dr. Malinowski. 9 p.m.

SATURDAY, FEBRUARY 14TH.

INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH, JUNIOR SECTION.—College of Technology, Sackville-street, Manchester. Lecture, "Some Foundry Experiences," by Mr. W. H. Meadowcroft. 7 p.m.

INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Queen's Hotel, Birmingham. Annual dinner.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Florence Restaurant, Rupert-street, London, W. 1. London Graduates' annual dinner. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—The College, Loughborough. Loughborough Graduates' meeting. 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS: WESTERN COUNTIES BRANCH.—Royal Institution, Swansea. Paper, "Piles and Pile Foundations," by Mr. G. B. R. Pimm. 6 p.m.

MONDAY, FEBRUARY 16TH.

BRADFORD ENGINEERING SOCIETY.—Technical College, Bradford. Lecture, "The Scientific Treatment of Boiler Feed Water, introducing the Application of Colloid Chemistry," by Mr. W. B. Lewis. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: BIRMINGHAM CENTRE.—Chamber of Commerce, New-street, Birmingham. Paper, "Some Notes on British Methods of Continuous Production," by Mr. F. G. Woollard. 7 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: SCOTTISH CENTRE.—Royal Technical College, Glasgow. Paper, "Marine Motor Installation," by Mr. C. H. Macmillan. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION.—Lecture Theatre of the Mining Institute, Neville Hall, Newcastle-upon-Tyne. Paper, "Some Recent Dry Dock Extensions," by Mr. E. Box. 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS: NORTH-WESTERN SECTION.—Geographical Society's Rooms, 16, St. Mary's Parsonage, Manchester. Lecture, "The Design and Construction of the No. 5 Gas Holder for Burnley Corporation," by Mr. A. D. Young. 7.15 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS: MIDDLESBROUGH BRANCH, GRADUATE SECTION.—St. George's Presbyterian Hall, Yarm-lane, Stockton-on-Tees. Paper, "Corrugated Ships," by Mr. G. R. Hutchinson. 8 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. Cantor Lecture, "The Inner Structure of Alloys—I.," by Dr. Walter Rosenhain. 8 p.m.

TUESDAY, FEBRUARY 17TH.

INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE. Freemasons' Hall, 96-98, George-street, Edinburgh. Faraday Lecture, "World-wide Radio Telegraphy," by Professor G. W. O. Howe. 7.45 p.m.

WEDNESDAY, FEBRUARY 18TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Chamber of Commerce, New-street, Birmingham. Birmingham Graduates' meeting. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, London, S.W. 1. Students' meeting. Paper, "Reconstruction of Barrow Haven Bridge, Lincolnshire, L. and N.E. Railway." by Mr. R. H. Tangri. 6 p.m.

ROYAL METEOROLOGICAL SOCIETY.—49, Cromwell-road, South Kensington, London, S.W. 7. Papers: "The Effect of Pressure Distribution upon London's Sunshine in Winter," by Miss Doris Sawyer; "On the Changes of Temperature in the Lower Atmosphere by Eddy Conduction and otherwise," by Professor S. Chapman; and "The Measurement of the Lapse Rate by an Optical Method," by Messrs. N. K. Johnson and O. F. Roberts. 7.30 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. "Modern Atmospheric Conditions," by Dr. J. S. Owens. 8 p.m.

THURSDAY, FEBRUARY 19TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Cavendish Café, Cornmarket, Derby. Derby Graduates' meeting. Lantern lecture, "The Early History of Road Transport," by Mr. R. Bolton. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Joint meeting with the Royal Aeronautical Society. Lecture, "Light Aeroplane Engine Developments," by Lieut.-Colonel L. F. R. Fell 7 p.m.

INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—Griffin Hotel, Bear-lane, Leeds. Paper, "The Elimination of Human Waste in Industry," by Mr. R. J. Mackay. 7.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—The Engineers' Club, Coventry-street, London, W. 1. "Vacuum Brake Ejectors," by Mr. J. N. Gresham. 7 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, Piccadilly, London, W. 1. Lecture, "Properties and Structure of Quartz—IV.," by Sir William Bragg. 5.15 p.m.

FRIDAY, FEBRUARY 20TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—London Graduates' visit to the Lighting Service Bureau of the Electric Lamp Manufacturers' Association, 15, Savoy-street, London, W.C. 2. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Queen's Hotel, Coventry. Coventry Graduates' fourth annual dinner. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT BRANCH.—Council Chamber, Council House, Birmingham. Annual joint meeting with the Institution of Mechanical Engineers, Midland Branch, and the Institution of Electrical Engineers, South Midland Centre. Subject, "Review of the Work of the First World Power Conference." 7 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND: STUDENTS' SECTION.—39, Elmbank-crescent, Glasgow. Paper, "Ship Design," by Professor P. A. Hillhouse. 8 p.m.

INSTITUTION OF ENGINEERING INSPECTION.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "The Radium Industry, its Development and Importance," by Major C. E. S. Phillips. 7.45 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—The Engineers' Club, Coventry-street, London, W. 1. Annual dinner. 6.30 for 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, Westminster, London, S.W. 1. Annual general meeting. Further discussion on "Anti-friction Bearing Applications." 6 p.m.

INSTITUTION OF PRODUCTION ENGINEERS.—Society of Motor Manufacturers and Traders, 83, Pall Mall, London, S.W. 1. Paper, "Grinding Practice," by Mr. H. A. Dean. 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Lecturette, "Inverted Tooth Chain Drives," by Mr. J. M. Seddon. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, Piccadilly, London, W. 1. Discourse, "Acquiring Muscular Skill," by Professor T. H. Pear. 9 p.m.

SATURDAY, FEBRUARY 21ST.

INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—The Grosvenor Restaurant, Gordon-street, Glasgow. Smoking concert. 7 p.m.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—North-Eastern District meeting at Blyth. 12.30 p.m.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Queen's Hotel, Keighley. Annual dinner. 5.45 p.m.

TUESDAY, FEBRUARY 24TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Broadgate Café, Coventry. Coventry Graduates' meeting. Paper, "The Testing of the Automobile," by Mr. R. N. Aveline. 7.15 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Society of Motor Manufacturers and Traders, 83, Pall Mall, London, S.W. 1. Informal meeting. Discussion on "Curious Breakdowns." 7 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, London, S.W. 1. Paper, "The Demolition of the Harbour and Defence Works of Heligoland," by Mr. L. H. Savile. 6 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Rankine Hall, Elmbank-crescent, Glasgow. Paper, "The Latest Type of the Burmeister and Wain Marine Diesel Engine," by Mr. H. H. Blache. 7.30 p.m.

WEDNESDAY, FEBRUARY 25TH.

ENGINEERING GOLFING SOCIETY.—Institution of Civil Engineers, Great George-street, Westminster, London, S.W. 1. Annual general meeting. 12 noon.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Birmingham Graduates' visit to the works of the Midland Motor Cylinder Company, Limited, and the Birmingham Aluminium Castings Company, Limited, Smethwick.

INSTITUTION OF AUTOMOBILE ENGINEERS: NORTH OF ENGLAND CENTRE.—Engineering Theatre of the University, Liverpool. Paper, "Marine Motor Installation," by Mr. C. H. Macmillan. 7 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE.—St. Bride Institute, Bride-lane, Fleet-street, London, E.C. 4. Discussion on "Responsibilities and Difficulties of the Engineer-in-Charge." 7.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS: GRADUATE SECTION.—The Mining Institute, Newcastle-upon-Tyne. "The Principle of Interference in Ship Waves and Ship Resistance," by Professor T. H. Havelock. 7.15 p.m.

THURSDAY, FEBRUARY 26TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Training School of Vauxhall Motors, Limited, Luton. Luton Graduates' meeting. Paper, "The Balancing of Automobile Engine Crank Shafts," by Mr. W. B. Draper. 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS.—Denison House, 296, Vauxhall Bridge-road, London, S.W. 1. Paper, "Reinforced Concrete Columns," by Mr. Edward Godfrey. 8 p.m.

FRIDAY, FEBRUARY 27TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Watergate House, Adelphi, London, W.C. 2. Graduates' meeting. Paper, "Why Pneumatic Tires?" by Mr. R. Marks. 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Lecturette, "A Treatise on Modern Lighting Practice," by Mr. E. Stroud. 7.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Literary and Philosophical Society, Newcastle-upon-Tyne. Paper, "Ultimate Possibilities of Steam Plant," by Professor A. L. Mellanby and Dr. W. Kerr. 7.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS: MIDDLESBROUGH BRANCH.—Graduate Section's visit to the works of Bolckow, Vaughan and Co., South Bank.

CONTRACTS.

CONTRACTS totalling £107,000 have been placed with Waygood Otis, Limited, for the construction of escalators at stations on the Morden Tube Extension of the London Electric Railways.

THE Birmingham Corporation has recently placed with Richard Garrett and Sons, Limited, of Leiston, a contract for the supply of a further twelve 5-ton end-tipping electrically propelled refuse-collecting vehicles.

VICKERS LIMITED have received an order for four low-temperature 4ft. diameter by 50ft. long fusion rotary retorts, to be installed at the Burghlee Colliery at Loanhead, Midlothian, of Messrs. W. Hunter and Sons, Edinburgh. This plant, which is being manufactured at the Barrow-in-Furness works of Vickers Limited, will work on colliery waste coal for the purpose of obtaining oil and other products. The electric winding engine jointly exhibited by Vickers Limited, Barrow-in-Furness, and Metropolitan-Vickers Electrical Company, Limited, at Wembley last year has been purchased by the Burradon and Coxlodge Coal Company, Newcastle-on-Tyne, for its Weetslade pit.